MONITORING REPORT

WSDOT Floating Bridge Stormwater Monitoring Project

Prepared for

Washington State Department of Transportation

June 2005

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Prepared for

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Contents

Tables

Figures

Introduction

The Washington State Department of Transportation (WSDOT) maintains and operates the following floating bridges in the Puget Sound region: Evergreen Point Floating Bridge (SR 520 Bridge), Homer M. Hadley Memorial Bridge (I-90 Bridge), and the Hood Canal Bridge (Figure 1). The SR 520 Bridge and I-90 Bridge both span Lake Washington and the Hood Canal Bridge spans the marine waters of Hood Canal.

Sampling conducted by King County in April 2003, October 2003, and January 2004 indicated that stormwater discharging from several downspouts on the SR 520 Bridge contained elevated concentrations of zinc and copper (King County 2004). In December 2004, WSDOT conducted additional sampling at the SR 520 Bridge downspouts and found similar elevated zinc and copper concentrations (WSDOT 2005). Finally, in December 2004, WSDOT collected sediment samples from the deck of the SR 520 Bridge in an effort to identify potential sources for the high concentrations of these metals in stormwater. The resultant data suggest that sediment on the SR 520 Bridge deck has slightly elevated concentrations of zinc and copper relative to sediment found in industrialized areas (WSDOT 2005).

Due to concerns over these elevated zinc and copper concentrations, Herrera Environmental Consultants (Herrera) was retained by WSDOT's Environmental Services Office to conduct additional stormwater monitoring on the SR 520 Bridge over the period of February through April 2005. In addition, Herrera conducted stormwater monitoring on the I-90 Bridge and WSDOT conducted stormwater monitoring on the Hood Canal Floating Bridge. The overall goals of this monitoring were to: 1) verify whether or not these elevated concentrations are unique to the SR 520 Bridge and not a characteristic of all floating bridges, and 2) identify potential sources for the elevated zinc and copper concentrations measured on the SR 520 Bridge. This monitoring was performed in accordance with sampling procedures, analytical methods, and schedules identified in the quality assurance project plan (QAPP) that was prepared earlier for the project (Herrera 2005).

This document is the final project report for the monitoring program described above. Accordingly, all data obtained during the monitoring program are compiled and summarized herein. To meet the stated goals of the monitoring program, this report also provides a comprehensive analysis of the collected data and a discussion of the relevant findings. The presentation of this information is organized under the following section headings within this report:

- Background and Problem Statement
- Monitoring Overview
- Methods
- Results and Discussion
- Conclusions and Recommendations.

Figure 1. Vicinity map for the Hood Canal Bridge, Evergreen Point Floating Bridge (SR 520 Bridge), and the Homer M. Hadley Memorial Bridge (I-90 Bridge), Washington.

Background and Problem Statement

As defined in WAC 173-201A, Washington State has established surface water quality standards for zinc and copper based on acute and chronic impacts to aquatic organisms. The standards for acute impacts are promulgated to prevent injury or death to an organism as a result of short-term exposure. In contrast, standards for chronic impacts are intended to prevent injury or death to an organism as a result of repeated or constant exposure over an extended period of time. The actual acute and chronics standards for zinc and copper are assessed based on 1-hour average and 4-day average concentrations, respectively, that may not be exceeded more than once every three years. The acute and chronic standards for zinc and copper are both based on the dissolved fractions of these metals and vary depending on water hardness.

As noted above, sampling conducted by King County in April 2003, October 2003, and January 2004 indicated that stormwater collected from several downspouts on the SR 520 Bridge contained elevated concentrations of zinc and copper (King County 2004). For example, the median and maximum dissolved zinc concentrations from this sampling were 0.609 and 3.15 mg/L, respectively. The median and maximum dissolved copper concentrations from this sampling were 0.0270 and 0.0684 mg/L, respectively. The raw data from this sampling effort are presented in Table 1.

Table 1. Zinc and copper concentrations from sampling conducted by King County on the SR 520 Bridge.

Sample Date	Station Identification	Dissolved Zinc (mg/L)	Total Zinc (mg/L)	Dissolved Copper (mg/L)	Total Copper (mg/L)
14-Jan-04	520BR-N1	1.70	2.23	0.0270	0.0530
14-Jan-04	520BR-N2	0.259	0.942	0.0253	0.0710
14-Jan-04	520BR-N3	0.422	1.24	0.0288	0.0696
6-Oct-03	520BR-N1	3.15	3.02	0.0419	0.0531
6-Oct-03	520BR-N2	2.02	1.95	0.0498	0.0636
6-Oct-03	520BR-N3	2.25	2.15	0.0684	0.0765
8-Apr-03	520BR-N1	0.609	0.756	0.0177	0.0385
8-Apr-03	520BR-N2	0.341	0.444	0.0155	0.0399
8-Apr-03	520BR-N3	0.292	0.427	0.0158	0.0360
Median		0.609	1.24	0.0270	0.0531
Minimum		0.259	0.427	0.0155	0.0360
Maximum		3.15	3.02	0.0684	0.0765

Source: King County 2004
mg/L = milligrams per liter.

In December 2004, WSDOT conducted additional sampling at the SR 520 Bridge downspouts and found similar elevated zinc and copper concentrations (WSDOT 2005). For example, the median and maximum dissolved zinc concentrations from this sampling were 0.697 and 1.12

mg/L, respectively. The median and maximum dissolved copper concentrations from this sampling were 0.016 and 0.019 mg/L, respectively. These concentrations are unusually high in comparison to zinc and copper concentrations measured in other WSDOT stormwater monitoring efforts (Tveten 2005 personal communication).

Based on an average water hardness of 37.2 mg/L for Lake Washington (King County 2003), the acute and chronic standards for dissolved zinc are 0.050 mg/L and 0.045 mg/L, respectively. At the same hardness, the acute and chronic standards for dissolved copper are 0.0067 mg/L and 0.0049 mg/L, respectively. Therefore, the high dissolved zinc and copper concentrations measured in stormwater discharge from the SR 520 Bridge likely exceed state water quality standards. This monitoring program was subsequently initiated due to concerns over these elevated zinc and copper concentrations.

Monitoring Overview

This monitoring program involved collecting stormwater samples from representative locations on the SR 520 Bridge, I-90 Bridge, and Hood Canal Bridge (see Figure 1). Sampling stations were established on each bridge to allow characterization of stormwater quality directly on the bridge deck and/or at selected discharge points for "downspouts" that drain the bridge deck. Because downspouts on the SR 520 Bridge are made of galvanized pipe material, they were identified as a likely source for the high metals concentrations during the planning phase of this project. To test whether zinc and copper concentrations are increasing with increased contact time with this pipe material, monitoring locations were specifically selected to evaluate concentrations of these metals in stormwater discharging from relatively long and short downspouts, respectively. In addition, one sampling station was established in association with the SR 520 Bridge for the collection of rainwater samples. Data from this station were used to determine background concentrations of metals in rainwater for comparison to concentrations measured in stormwater at the bridge sampling locations.

Stormwater samples from the SR 520 Bridge and I-90 Bridge were collected by Herrera personnel whereas stormwater samples on the Hood Canal Bridge were collected by WSDOT personnel. In all cases, sampling was performed in accordance with quality assurance procedures that were previously identified in the QAPP for the project (Herrera 2005).

Methods

The monitoring schedule, sampling locations, sampling design for stormwater and rainwater, field procedures, and analytical procedures used during this monitoring project are described briefly in the following sections. These procedures were originally presented in the QAPP that was developed for this project (Herrera 2005).

Based on preliminary stormwater monitoring data that indicated bridge downspouts were a potential source for the elevated zinc in stormwater, additional metallurgical analyses were also performed on downspout pipe samples obtained from two of the bridges. The methods used in these analyses are also briefly described herein.

Schedule

Stormwater monitoring associated with this study was initiated in February and concluded in April 2005. A total of three storm events were sampled for characterizing stormwater quality on the SR 520 Bridge. In addition, sampling was also conducted on one occasion while WSDOT personnel were performing routine cleaning operations on the SR 520 bridge using water from a tanker truck. The I-90 Bridge was also sampled during one storm event and the Hood Canal Bridge during two events. The specific dates for these sampling events are presented in Table 2.

Table 2. Sampling dates for monitoring conducted on the SR 520 Bridge, I90 Bridge, and Hood Canal Bridge

SR 520 Bridge	I-90 Bridge	Hood Canal Bridge
3/19/05	3/26/05	3/19/05
3/24/05[a]		4/7/05
3/26/05		
4/1/05		

[a] Sampling on this date occurred while routine cleaning operations were being performed on the SR 520 bridge using water from a tanker truck.

Based on data from the National Weather Service meteorological station located at the Sand Point Naval Air Station, 24-hour precipitation totals for the storm events above ranged from 0.32 to 1.29 inches.

Sampling Locations

Stormwater sampling locations established for the SR 520 Bridge, I-90 Bridge, and Hood Canal Bridge are described in separate subsections below.

SR 520 Bridge

Sampling stations for the SR 520 Bridge were selected to characterize stormwater quality directly on the bridge deck and at selected discharge points for relatively long and short downspouts that convey stormwater from the bridge deck. In total, three stations were established for monitoring stormwater quality on the bridge deck and eight stations were established for monitoring stormwater quality at discharge points for the downspouts. The approximate location of these stations is shown in Figure 2 and a detailed description of each is provided in Table 3. Each of these stations is also described briefly herein.

Table 3. Stormwater monitoring locations for the Evergreen Point Floating Bridge (SR 520 Bridge), Seattle, Washington.

Station	Type	Description	Pontoon[a]	Bent
DE-S4	Bridge Deck	Sample collected where runoff from bridge deck drips through construction joint for adjoining roadway sections; west end of bridge and eastbound lane.	D	31D
DE-S9	Bridge Deck	Sample collected where runoff from bridge deck drips through construction joint for adjoining roadway sections; east end of bridge and eastbound lane.	X	38B
DE-Drawspan	Bridge Deck	Sample collected where concentrated roadway runoff from the bridge deck collects in small service area associated with the drawspan; middle of bridge and westbound lane.	P	NA
DS-N4	Short Downspout	Outlet of short downspout for bridge deck runoff on west end of bridge and westbound lane.	D	31A
DS-S4	Short Downspout	Outlet of short downspout for bridge deck runoff on west end of bridge and westbound lane.	D	31D
DS-N9	Short Downspout	Outlet of short downspout for bridge deck runoff on east end of bridge and westbound lane.	X	38A
DS-S9	Short Downspout	Outlet of short downspout for bridge deck runoff on east end of bridge and eastbound lane.	X	38B
DS-N1	Long Downspout	Outlet of long downspout for bridge deck runoff on west end of bridge and westbound lane.	B	4A
DS-S1	Long Downspout	Outlet of long downspout for bridge deck runoff on west end of bridge and eastbound lane.	B	4E
DS-N20	Long Downspout	Outlet of long downspout for bridge deck runoff on east end of bridge and westbound lane.	Z	65A
DS-S20	Long Downspout	Outlet of long downspout for bridge deck runoff on east end of bridge and eastbound lane.	Z	65A

[a] Pontoons for the SR 520 Bridge are identified by successive letters of the alphabet starting with A for the first pontoon on the west end of the bridge and ending with AA for the last pontoon on the east end of the bridge.
[b] Individual pontoons for SR 520 Bridge are divided into subsections identified by bent number.

Stations DE-S4, DE-S9, and DE-Drawspan were established for characterizing stormwater quality directly on the bridge deck. As shown in Figure 2, stations DE-S4 and DE-S9 are both located on the south side of the bridge and in the western and eastern high-rise sections of the bridge, respectively. (In the eastern and western high-rise sections of the bridge, the roadway is elevated on pillars that are set on the bridge's pontoons. The deck of the pontoons is open and floats about four feet above the lake water surface.) At these locations, runoff from the bridge

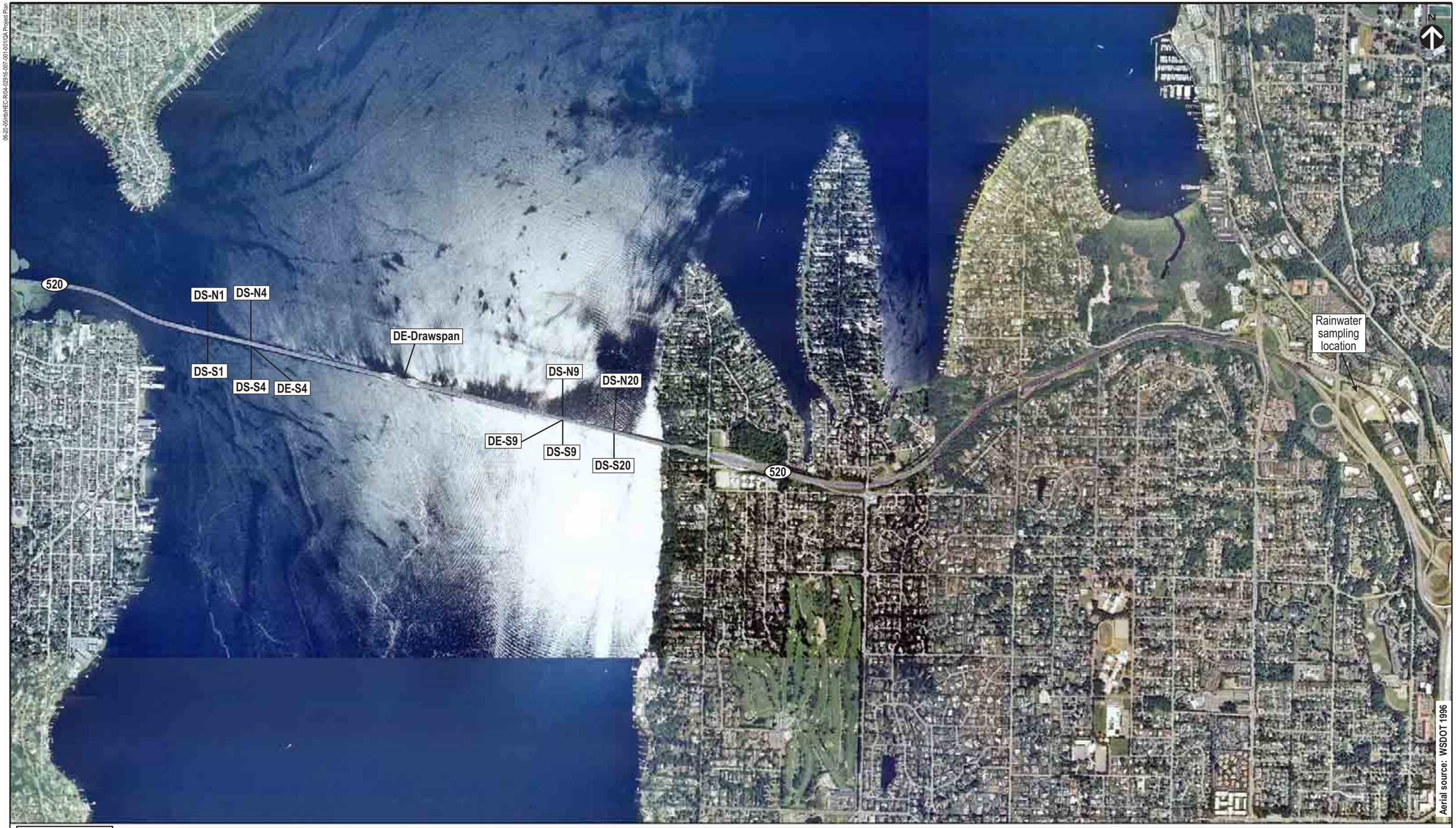

Figure 2. Stormwater monitoring locations for the Evergreen Point Floating Bridge (SR 520 Bridge), Seattle, Washington.

deck can be collected as it drips through the construction joint for two adjoining sections of elevated roadway. The third bridge deck station, DE-Drawspan, is located near the drawspan structure at the center of the bridge. Concentrated roadway runoff from the bridge deck can be intercepted at this location as it passes through a small service area associated with the drawspan.

In the high-rise sections of the bridge, each 90-foot length of roadway has a small catchbasin set in a gutter running along the outermost lane in each traffic direction. Roadway runoff from these catchbasins is collected in 4-inch diameter downspouts that are made of galvanized steel. The downspouts run vertically along the outside of the support pillars for the elevated roadway and terminate at a 45-degree bend about 24-inches above the pontoon deck. Roadway runoff discharges directly to the lake from the ends of these downspouts. The following eight stations were established for characterizing stormwater quality at discharge points for these downspouts: DS-N1, DS-N4, DS-N9, DS-N20, DS-S1, DS-S4, DS-S9, and DS-S20. The approximate location of these stations is shown in Figure 2. The downspouts are longest at the elevated ends of the bridge and gradually become shorter as one moves towards the middle of the bridge. Stations DS-N4, DS-S4, DS-N9, and DS-S9 are associated with relatively short downspouts (i.e., length <20 feet) whereas stations DS-N1, DS-S1, DS-N20, and DS-S20 are associated with longer downspouts (i.e., length > 30 feet).

Finally, a separate monitoring station for collecting rainwater samples was established at the WSDOT road maintenance facility located at 10833 Northrup Way NE in Bellevue, WA (see Figure 2). This facility is located directly adjacent to SR 520 and approximately 3 kilometers from the east end of the SR 520 Bridge.

I-90 Bridge

A total of four monitoring stations were established on the I-90 Bridge to characterize stormwater quality on the bridge deck and at selected discharge points for downspouts draining the bridge deck. Bridge deck stations HH-DE-1 and LUM-DE-1 are located in gutters running along the outer most lanes for the westbound and eastbound spans, respectively, of the I-90 Bridge. Downspout stations HH-DS-1 and LUM-DS-1 are located at discharge points for downspouts draining the westbound and eastbound spans, respectively. Due to the drainage configuration of the I-90 Bridge, only long downspouts were available for sampling.

Hood Canal Bridge

A total of three monitoring stations were established on the Hood Canal Bridge to characterize stormwater quality on the bridge deck and at selected discharge points for relatively long and short downspouts draining the bridge deck. The WEST DRAIN station is located in association with the deck for the bridge's westbound lane. The EAST DOWNSPOUT – 10 FT and EAST DOWNSPOUT – 40 FT stations are located at discharge points for long and short downspouts, respectively, draining the deck of the eastbound lane of the bridge. Because the EAST DOWNSPOUT -40 FT station was added midway through the study, it was only sampled during the April 7 storm event (see Table 2).

Stormwater Sampling Design

During this monitoring program, the following conditions were targeted when determining the acceptability of specific storm events for sampling:

- **Target storm depth:** A minimum of 0.25 inches of precipitation over a 24-hour period.
- **Antecedent conditions:** A period of at least 6 hours preceding the event with less than 0.04 inches of precipitation.

Weather forecast information from the King 5 weather website (http://www.king5.com/weather/) and precipitation amount predictions from the Institute of Global Environment and Society, Center for Ocean-Land-Atmosphere Studies (http://grads.iges.org/pix/quicklook.html) were reviewed on a weekly basis to determine if a predicted storm event was likely to meet the storm event criterion above. To evaluate precipitation conditions immediately prior to sampling, the King 5 weather website (http://www.king5.com/weather/) was used to observe the Doppler radar display and obtain real-time precipitation data for School Net sites located at the Pacific Science Center in downtown Seattle and at Kings Elementary School in north Seattle. To document precipitation conditions upon completion of sampling, hourly precipitation data were compiled from the National Weather Service meteorological station located at the Sand Point Naval Air Station.

During each sampled storm event, one grab sample was collected from the monitoring stations described above. This sampling was conducted using protocols established for the low level detection of metals as described in the *Field Procedures* section below.

Rainwater Sampling Design

Prior to initiating any stormwater sampling activities on the SR 520 Bridge, Herrera field personnel deployed a rainwater sampling device at the WSDOT road maintenance facility described in the *Sampling Locations* section above. This sampling device consisted of a bottle and funnel mounted on an extendable pole with a maximum height of 14 feet. Once deployed, this sampling device was left in place to collect rainwater while activities related to the SR 520 Bridge stormwater sampling were being carried out. Upon completion of these activities, field personnel retrieved the sampling device and associated rainwater sample. When handing the rainwater sample, field personnel followed the protocols described in the *Field Procedures* section below for low level detection of metals. The sampling device was subsequently decontaminated between storm events using the procedures described in the QAPP developed for the project (Herrera 2005).

Field Procedures

Water was collected as grab samples from each station during the selected storm events. The sample collection was conducted using a modified version of the "clean hands" and "dirty hands" protocol developed by the U.S. Environmental Protection Agency (U.S. EPA) (1996) for low-level detection of metals. This modified version of the protocol is described in detail in Appendix A of this report.

Stormwater Analytical Procedures

As noted above, grab samples were collected for the analysis of total and dissolved copper, and total and dissolved zinc. Laboratory analytical procedures for these parameters followed methods that are approved by the U.S. Environmental Protection Agency (APHA et al. 1992; U.S. EPA 1983, 1984). These methods provide reporting limits that are below applicable state water quality standards and allow direct comparison of the analytical results to these standards. The preservation methods, analytical methods, reporting limits, and sample holding times are presented in Table 4.

Table 4. Methods and detection limits for water quality analyses.

Parameter	Bottle Type	Preservation Method	Analytical Method	Method Number	Reporting Limit [a]	Sample Holding Times
Copper, dissolved	P	Cool, 4°C; filtration, 0.45 µm; HNO_3 to pH<2	GFAA	EPA 220.2	0.001 mg/L	6 months [b]
Copper, total	P	Cool, 4°C; HNO_3 to pH<2	GFAA	EPA 220.2	0.001 mg/L	6 months
Zinc, dissolved	P	Cool, 4°C; filtration, 0.45 µm; HNO_3 to pH<2	ICP	EPA 200.7	0.005 mg/L	6 months [b]
Zinc, total	P	Cool, 4°C; HNO_3 to pH<2	ICP	EPA 200.7	0.005 mg/L	6 months

[a] Reporting limit refers to the practical quantitation limit.
[b] Sample filtration and/or preservation will occur within 12 hours of sample collection.
GFAA = graphite furnace atomic absorption.
ICP = inductively coupled plasma.
mg/L = milligrams per liter.
P = polyethylene, polypropylene, fluoropolymer.

When feasible, samples for parameters requiring filtration (i.e., dissolved copper and zinc) were delivered to the laboratory within 12 hours of their collection. Upon their receipt, laboratory personnel immediately filtered and preserved these samples.

The laboratory used for this project (Aquatic Research, Inc.) is certified by Ecology and participates in audits and interlaboratory studies by Ecology and U.S. EPA. These performance and system audits have verified the adequacy of the laboratory's standard operating procedures, which include preventive maintenance and data reduction procedures.

The laboratory reported the analytical results within 30 days of receipt of the samples and provided sample and quality control data in standardized reports that are suitable for evaluating the project data. The reports also include a case narrative summarizing any problems encountered in the analyses.

Metallurgical Analysis Procedures

Metallurgical analyses were performed on samples of pipe material from downspouts to determine if the downspouts were potential sources for the high zinc concentrations measured in stormwater discharge from the SR 520 Bridge. In order to perform these analyses, an approximately 4-inch section of pipe was cut from a representative downspout on the SR 520 Bridge. A 4-inch section of pipe was also cut from a representative downspout on the Hood Canal Bridge to serve as a control in these analyses from a bridge without unusually high stormwater zinc concentrations. Both of these samples were sent to a metallurgical laboratory (Dwight Company, Inc.; Chehalis, WA) where the following analyses were performed:

- Metallurgical analyses to determine the zinc content of the base pipe material.
- Visual examinations of pipe cross sections using microscopy to determine the thickness of any remaining galvanized plating.
- Metallurgical analysis using microprobe to determine the zinc content of any remaining galvanized plating.

Data Management Procedures

Stormwater monitoring data reported by Aquatic Research, Inc. were entered into an Excel spreadsheet with one row for each sample. The spreadsheet included columns for entering the sample date, sample time, event type, station identification, and replicate sample number. The data entry was independently reviewed by Herrera's quality assurance officer by comparing recorded sample values in the spreadsheet to the laboratory reports.

Results and Discussion

Results from this monitoring program are summarized and discussed in the sections below. The presentation of these results is organized into separate subsections for each of the following study components: 1) stormwater quality monitoring on the SR 520 Bridge, I-90 Bridge, and Hood Canal Bridge, and 2) metallurgical analyses performed on pipe samples from bridge downspouts on the SR 520 Bridge and Hood Canal Bridge. Additional supporting information for these subsections is provided in Appendices A through D. For example, Appendix A presents the data quality assurance report for the project. All collected stormwater quality data are tabulated in a database that is presented in Appendix B; and the associated laboratory reports, chain-of-custody records, and data quality assurance worksheets are provided in Appendix C. Finally, the laboratory report generated from the metallurgical analyses is provided in Appendix D.

Stormwater Quality Monitoring

Zinc and copper concentrations from stormwater sampling conducted on the SR 520 Bridge, I-90 Bridge, and Hood Canal Bridge are summarized in Tables 5 and 6, respectively. Each table presents separate summary statistics for the dissolved and total forms of these metals by bridge location, type of station (e.g., bridge deck, downspout), and individual station. The results for zinc and copper are summarized in separate subsections. Each subsection begins with a broad comparison of concentrations measured on each of the three bridges. Monitoring results from the different types of sampling locations are then presented and compared separately for each individual bridge.

Total and Dissolved Zinc

Monitoring data from this study indicate that the SR 520 Bridge had substantially higher concentrations of zinc in stormwater samples relative to the I-90 Bridge and Hood Canal Bridge (Table 5). For example, the median total zinc concentration for all monitoring stations on the SR 520 Bridge was approximately twice as high as the median values for sampling stations on the I-90 Bridge and Hood Canal Bridge. Similarly, the median dissolved zinc concentration for stations on the SR 520 Bridge was approximately six times higher than the median value for stations on the I-90 Bridge. However, the median dissolve zinc concentration for the SR 520 Bridge was only slightly higher than the median value for the Hood Canal Bridge.

There was an even greater disparity between the bridges based on their maximum zinc concentrations (Table 5). For example, the maximum total and dissolved zinc concentrations for stations on the SR 520 Bridge were approximately 80 times higher than the maximum values for stations on the I-90 Bridge and Hood Canal Bridge. These results suggest the elevated concentrations of zinc measured on the SR 520 Bridge are unique to this bridge and not a characteristic of all floating bridges.

Table 5. Total and dissolved zinc concentrations (mg/L) measured at sampling stations on the Evergreen Point Floating Bridge, Homer H. Hadley Bridge, and Hood Canal Bridge; winter 2005.

Station ID	n	Total Zinc			Dissolved Zinc		
		Median	Minimum	Maximum	Median	Minimum	Maximum
Evergreen Point Floating Bridge (SR 520 Bridge)							
Bridge Deck							
DE-S4	4	0.166	0.064	0.334	0.084	0.065	0.142
DE-Drawspan	4	0.148	0.098	0.225	0.073	0.027	0.263
DE-S9	4	0.247	0.127	0.296	0.105	0.078	0.121
All Bridge Deck Stations	12	0.172	0.064	0.334	0.095	0.027	0.263
Short Downspout							
DS-N4	4	0.176	0.077	0.251	0.136	0.073	0.171
DS-S4	4	0.158	0.069	0.409	0.122	0.047	0.420
DS-N9	4	0.156	0.115	0.220	0.095	0.076	0.211
DS-S9	4	0.177	0.103	0.239	0.101	0.036	0.145
All Short Downspout Stations	16	0.167	0.069	0.409	0.107	0.036	0.420
Long Downspout							
DS-N1	4	0.626	0.204	0.988	0.599	0.121	0.855
NS-S1	4	5.84	0.866	8.07	3.52	0.876	7.31
DS-N20	1	1.03	1.03	1.03	0.875	0.875	0.875
DS-S20	1	1.65	1.65	1.65	1.61	1.61	1.61
All Long Downspout Stations	10	1.01	0.204	8.07	0.876	0.875	7.31
All Stations	38	0.206	0.064	8.07	0.121	0.027	7.31
Homer M. Hadley Memorial Bridge (I-90 Bridge)							
Bridge Deck							
HH-DE-1	1	0.019	0.019	0.019	0.009	0.009	0.009
LUM-DE-1	1	0.064	0.064	0.064	0.019	0.019	0.019
All Bridge Deck Stations	2	0.042	0.019	0.064	0.014	0.009	0.019
Long Downspout							
HH-DS-1	1	0.095	0.095	0.095	0.019	0.019	0.019
LUM-DS-1	1	0.110	0.110	0.110	0.071	0.071	0.071
All Downspout Stations	2	0.103	0.095	0.110	0.045	0.019	0.071
All Stations	4	0.080	0.019	0.110	0.019	0.009	0.071
Hood Canal Bridge							
Bridge Deck							
West Drain	2	0.034	0.022	0.045	0.013	0.006	0.02
Short Downspout							
East Downspout - 10 foot	2	0.115	0.105	0.124	0.094	0.088	0.099
Long Downspout							
East Downspout - 40 foot	1	0.127	0.127	0.127	0.099	0.099	0.099
All Stations	5	0.105	0.022	0.127	0.088	0.006	0.099
Rainwater							
WSDOT facility on Northrup Way NE	3	0.010	0.008	0.011	0.009	0.007	0.011

mg/L: milligrams/liter

Table 6. Total and dissolved copper concentrations (mg/L) measured at sampling stations on the Evergreen Point Floating Bridge, Homer H. Hadley Bridge, and Hood Canal Bridge; winter 2005.

Station ID	n	Total Copper			Dissolved Copper		
		Median	Minimum	Maximum	Median	Minimum	Maximum
Evergreen Point Floating Bridge (SR 520 Bridge)							
Bridge Deck							
DE-S4	4	0.0356	0.0240	0.0710	0.0182	0.0120	0.0640
DE-Drawspan	4	0.0196	0.0110	0.0330	0.0080	0.0049	0.0230
DE-S9	4	0.0638	0.0170	0.0940	0.0239	0.0080	0.0450
All Bridge Deck Stations	12	0.0300	0.0110	0.0940	0.0181	0.0049	0.0640
Short Downspout							
DS-N4	4	0.0343	0.0170	0.0570	0.0160	0.0086	0.0550
DS-S4	4	0.0241	0.0110	0.0680	0.0166	0.0070	0.0570
DS-N9	4	0.0340	0.0164	0.0430	0.0120	0.0094	0.0380
DS-S9	4	0.0456	0.0100	0.0770	0.0213	0.0040	0.0520
All Short Downspout Stations	16	0.0301	0.0100	0.0770	0.0160	0.0040	0.0570
Long Downspout							
DS-N1	4	0.0166	0.0100	0.0810	0.0106	0.0060	0.0800
NS-S1	4	0.0251	0.0140	0.0480	0.0145	0.0097	0.0440
DS-N20	1	0.0225	0.0225	0.0225	0.0119	0.0119	0.0119
DS-S20	1	0.0219	0.0219	0.0219	0.0172	0.0172	0.0172
All Long Downspout Stations	10	0.0211	0.0100	0.0810	0.0130	0.0060	0.0800
All Stations	38	0.0270	0.0100	0.0940	0.0150	0.0040	0.0800
Homer M. Hadley Memorial Bridge (I-90 Bridge)							
Bridge Deck							
HH-DE-1	1	0.0110	0.0110	0.0110	0.0080	0.0080	0.0080
LUM-DE-1	1	0.0190	0.0190	0.0190	0.0090	0.0090	0.0090
All Bridge Deck Stations	2	0.0150	0.0110	0.0190	0.0085	0.0080	0.0090
Long Downspout							
HH-DS-1	1	0.0260	0.0260	0.0260	0.0070	0.0070	0.0070
LUM-DS-1	1	0.0130	0.0130	0.0130	0.0080	0.0080	0.0080
All Downspout Stations	2	0.0195	0.0130	0.0260	0.0075	0.0075	0.0075
All Stations	4	0.0160	0.0110	0.0260	0.0080	0.0070	0.0090
Hood Canal Bridge							
Bridge Deck							
West Drain	2	0.0077	0.0063	0.0091	0.0046	0.0042	0.0051
Short Downspout							
East Downspout - 10 foot	2	0.0104	0.0050	0.0158	0.0065	0.0023	0.0107
Long Downspout							
East Downspout - 40 foot	1	0.0061	0.0061	0.0061	0.0039	0.0039	0.0039
All Stations	5	0.0063	0.0050	0.0158	0.0042	0.0023	0.0107
Rainwater[a]							
WSDOT facility on Northrup Way NE	2	0.0020	0.0010	0.0030	0.0020	0.0010	0.0030

[a] Copper concentrations were below the detection limit in all rainwater samples.

mg/L: milligrams/liter

Comparisons of data from the different types of sampling locations on the SR 520 Bridge indicated that samples collected from long downspout stations had substantially higher zinc concentrations relative to those from the bridge deck and short downspout stations (Table 5, Figure 3). For example, the median total zinc concentration for long downspout stations was approximately six times higher than the median concentrations for short downspout and bridge deck stations. Similarly, the median dissolved zinc concentration for long downspout stations was approximately nine times higher than the median concentrations for the short downspout and bridge deck stations. Statistical analyses performed on these data using a Kruskal-Wallis test and follow-up nonparametric multiple comparison test indicated that the observed differences in zinc concentrations between the long downspout stations and the short downspout and bridge deck stations were statistically significant ($\propto = 0.05$). However, concentrations measured at the short downspout and bridge deck stations were not shown to be significantly different. These data suggest that zinc concentrations in the collected stormwater are increasing as the contact time with the pipe material increases within the longer downspouts.

It should also be noted that the highest concentrations of total and dissolved zinc concentrations were generally observed in samples collected from long downspout station DS-N1. Field observations indicated that the inlet to this downspout was almost completely blocked by asphalt. As a result, stormwater generally trickled into the inlet and subsequently moved through the downspout at a much lower flow rate relative to stormwater in other downspouts. Again, this would suggest that zinc concentrations are tending to increase as contact times with the downspout pipe material increases.

The chemical form of zinc in samples from the SR 520 Bridge also appeared to vary by sampling location type. Specifically, samples from long downspout stations tended to have higher dissolved to total zinc ratios relative to samples from short downspout and bridge deck stations. For example, median dissolved to total zinc ratios for samples collected from long downspout, short downspout, and bridge deck stations were 0.89, 0.76, and 0.62, respectively. Statistical analyses (i.e., Kruskal-Wallis test and follow-up nonparametric multiple comparison test) performed on these data indicated that ratios for long downspout stations were significantly higher ($\propto = 0.05$) than those for short downspout and bridge deck stations. The ratios for short downspout and bridge deck stations were not shown to be significantly different. These data suggest that dissolved zinc concentrations in the collected stormwater are increasing as the contact time with the pipe material increases within the longer downspouts.

Zinc concentrations measured on the I-90 Bridge also tended to be higher in samples from downspout stations relative to those from bridge deck stations, though this tendency was less pronounced relative to the same results from the SR 520 Bridge (Table 5, Figure 3). For example, total and dissolved zinc concentrations on the I-90 Bridge were approximately two to three times higher in samples from long downspout stations compared to those from the bridge deck stations. However, there was no clear trend evident in dissolved to total zinc ratios in relation to samples collected from downspout and bridge deck stations. For example, the median dissolved to total zinc ratios for downspout and bridge deck stations on the I-90 Bridge were 0.39 and 0.42, respectively. (Note that the statistical significance of these differences could not be assessed because of the small sample size.)

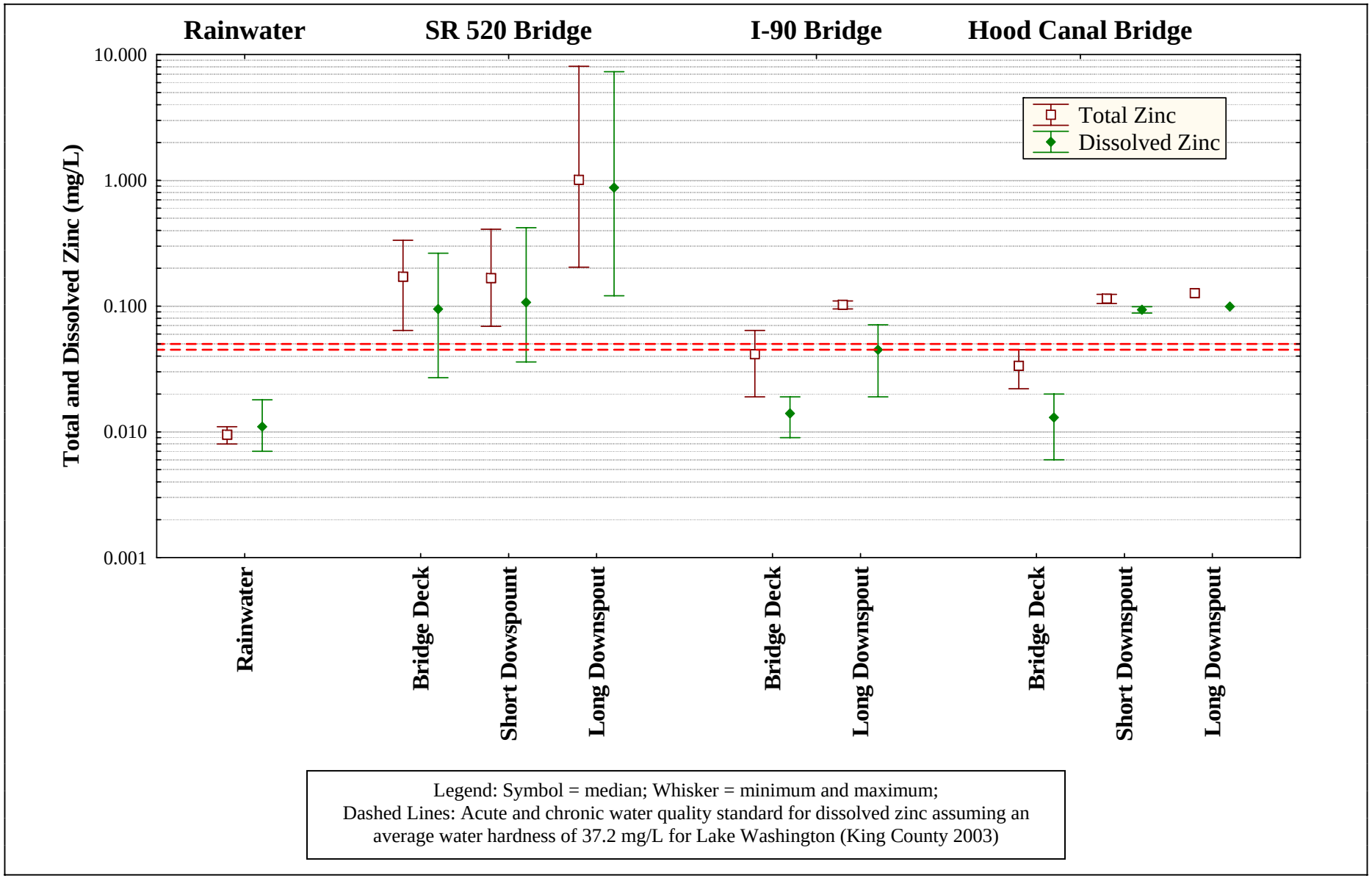

Figure 3. Total and dissolved zinc concentrations measured in stormwater at sampling stations on the Evergreen Point Floating Bridge (SR 520 Bridge), Homer M. Hadley Memorial Bridge (I-90 Bridge), and Hood Canal Bridge; winter 2005.

Unlike the SR 520 Bridge, zinc concentrations measured on the Hood Canal Bridge tended to be similar between samples collected from the long and short downspout stations (Table 5, Figure 3). However, samples from both types of downspout stations had higher zinc concentrations relative to those collected from the bridge deck station. For example, total and dissolved zinc concentrations on the Hood Canal Bridge were approximately three to eight times higher in samples from the downspout stations in comparison to those from the bridge deck station. Dissolved to total zinc ratios were also higher in samples collected from the downspout stations. For example, median dissolved to total zinc ratios for samples collected from the long downspout, short downspout, and bridge deck stations were 0.78, 0.82, and 0.36, respectively. (Note the statistical significance of these differences could not be assessed because of the small sample size.) These data suggest that the downspouts on the Hood Canal Bridge may also be a potential source of zinc in stormwater.

Total and Dissolved Copper

Copper concentrations (Table 6) were generally higher in stormwater samples from the SR 520 Bridge relative to the I-90 Bridge and Hood Canal Bridge, though this difference was less pronounced when compared to the results for zinc. For example, median total and dissolved copper concentrations for all monitoring stations on the SR 520 Bridge were approximately two to four times higher than the median values for sampling stations on the I-90 Bridge and Hood Canal Bridge. Similarly, maximum total and dissolve copper concentrations for stations on the SR 520 Bridge were approximately four to eight times higher than the maximum values for sampling stations on the other two bridges.

In contrast to the results for zinc, statistical analyses (i.e., Kruskal-Wallis test and follow-up nonparametric multiple comparison test) performed on the data from the SR 520 Bridge showed there were no significant differences ($\propto = 0.05$) in total or dissolved copper concentrations between samples collected at long downspout, short downspout, and bridge deck stations (Table 6, Figure 4). There were also no significant differences ($\propto = 0.05$) in dissolved to total copper ratios between samples collected from the different station types on the SR 520 Bridge. The median dissolved to total copper ratio was 0.59 for all stations combined. These results suggest that downspouts on the SR 520 Bridge are not a primary source for copper in stormwater.

There also appeared to be no substantial difference in total and dissolved copper concentrations between samples collected at downspout and bridge deck stations on the I-90 Bridge and Hood Canal Bridge (Table 6, Figure 4). Furthermore, there was no clear trend evident in dissolved to total copper ratios on either bridge in relation to their respective station types. For example, the median dissolved to total copper ratios for samples collected from downspout and bridge deck stations on the I-90 Bridge were 0.44 and 0.60, respectively. Likewise, median dissolved to total copper ratios for samples collected from the long downspout, short downspout, and bridge deck stations on the Hood Canal Bridge were 0.64, 0.57, and 0.61, respectively. (Note that the statistical significance of these differences could not be assessed because of the small sample size.) Similar to the SR 520 Bridge, these data suggest that downspouts on both the I-90 Bridge and Hood Canal Bridge do not appear to be a source for copper in stormwater.

Metallurgical Analyses

Results from the downspout metallurgical analyses are presented in detail in Appendix A. The key findings from these analyses are as follows:

- The base metal in downspout pipe samples from both the SR 520 Bridge and Hood Canal Bridge did not contain detectable levels of zinc.
- Examination of metallographic sections revealed features that are consistent with galvanized coating on the inner and outer surface of the downspout pipe sample from the SR 520 Bridge, and inner surface only of the Hood Canal Bridge. Energy dispersive x-ray (EDX) analyses performed on these surfaces indicated the presence of zinc and iron that is also consistent with galvanized coating.
- Microscopic examinations suggested there was substantial corrosion of the galvanized coatings on both the SR 520 Bridge and Hood Canal Bridge downspout pipe samples.
- Microscopic examinations also indicated there were major differences between the inner coatings of the pipe samples from the SR 520 Bridge and Hood Canal Bridge; specifically, the inner coating of the SR 520 Bridge pipe sample showed evidence of a relatively common manufacturing defect for galvanized materials (i.e., dross deposits). This defect likely contributed to increased cell corrosion on the inner coating of the pipe material and accelerated zinc leaching rates.

Like the results from the stormwater monitoring component of this study, results from these limited metallurgical analyses generally support the conclusion that the downspouts on the SR 520 Bridge are the source for the elevated zinc in stormwater. However, this conclusion is predicated on the assumption that other downspouts on the SR 520 Bridge possess the same defect as the pipe sample that was submitted for testing.

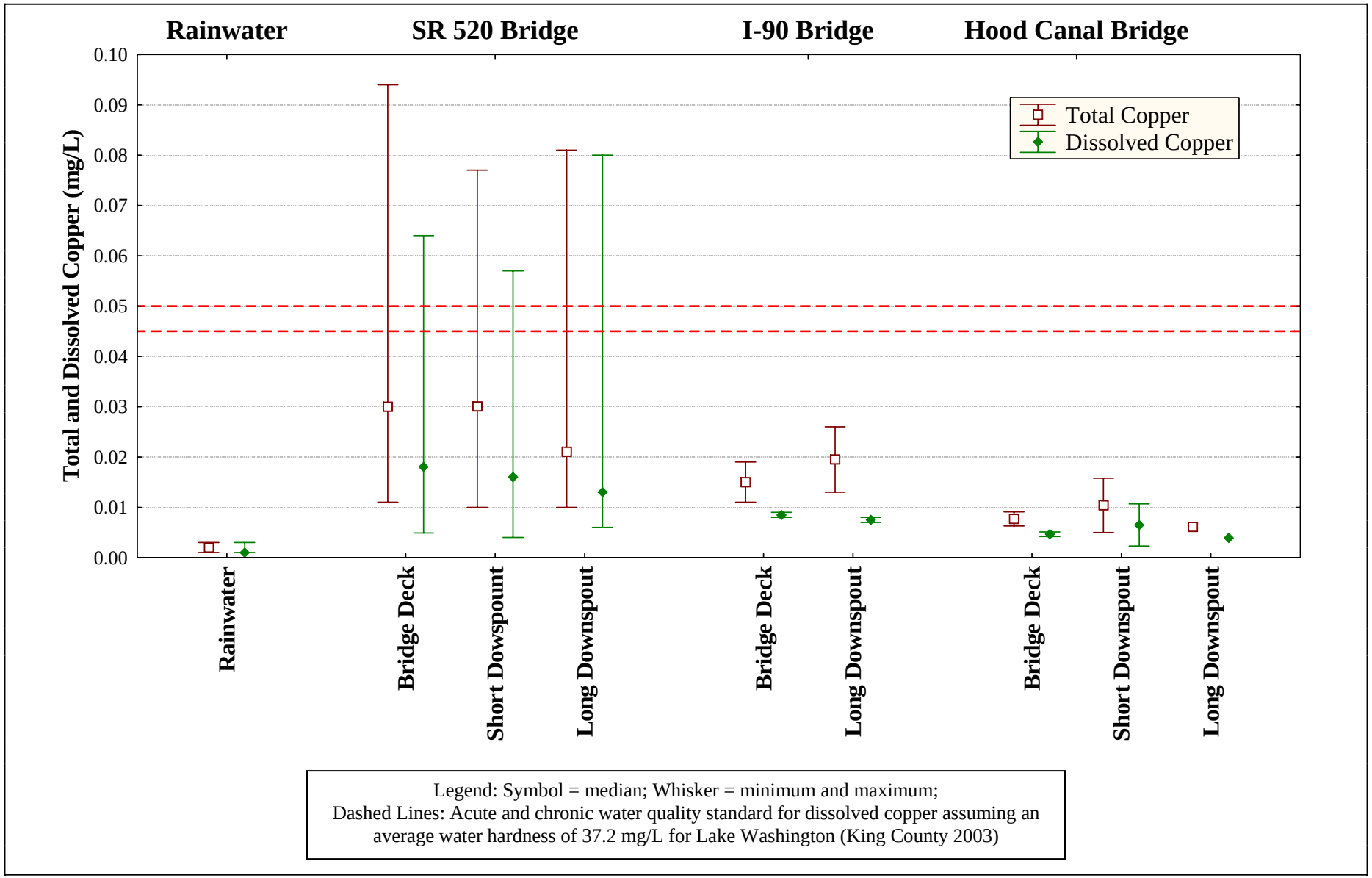

Figure 4. Total and dissolved copper concentrations measured in stormwater at sampling stations on the Evergreen Point Floating Bridge (SR 520 Bridge), Homer M. Hadley Memorial Bridge (I-90 Bridge), and Hood Canal Bridge; winter 2005.

Conclusions

As noted in the Introduction, this monitoring program was implemented in response to concerns over elevated zinc and copper concentrations that were measured previously in stormwater discharge from the SR 520 Bridge by King County and WSDOT. The overall goals of this monitoring were to: 1) verify whether or not these elevated concentrations are unique to the SR 520 Bridge and not a characteristic of all floating bridges, and 2) identify potential sources for the elevated zinc and copper concentrations measured on the SR 520 Bridge.

The key findings from this monitoring program are summarized as follows:

- The SR 520 Bridge had substantially higher concentrations of zinc in stormwater samples relative to samples collected from the I-90 Bridge and Hood Canal Bridge. These results suggest the elevated concentrations of zinc measured on the SR 520 Bridge are an isolated occurrence and not a characteristic of all floating bridges.

- Copper concentrations were generally higher in stormwater samples from the SR 520 Bridge relative to samples from the I-90 Bridge and Hood Canal Bridge, although this difference was much less pronounced in comparison to the results for zinc.

- Downspouts on the SR 520 Bridge appeared to be the source for the elevated zinc in stormwater. This conclusion is based on data that showed zinc concentrations were higher in samples from long downspouts stations in comparison to those from short downspout and bridge deck stations.

- The limited metallurgical analyses performed for this study suggest the elevated concentrations of zinc measured in stormwater samples from the SR 520 Bridge may be related to manufacturing defects in the galvanized coating on the bridge's downspouts.

- Downspouts on the SR 520 Bridge did not appear to be a source for copper in stormwater samples.

- Monitoring data from the I-90 Bridge and Hood Canal Bridge suggest that the downspouts on these bridges are a potential source for zinc in stormwater, although this trend was much less pronounced when compared to the results for the SR 520 Bridge. However, the statistical significance of these trends could not be evaluated due to the small sample size.

Based on these conclusions, it is recommended that WSDOT review its standard specifications and inspection procedures to ensure that galvanized materials for highway projects are free from defects that might otherwise contribute to excessive concentrations of zinc in stormwater.

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APPENDIX A

Data Quality Assurance Report

Data Quality Assurance Report

This report presents validation results for stormwater quality data collected through the WSDOT Floating Bridge Stormwater Monitoring Project. The overall goal of this report is to ensure that data of a known and acceptable quality are provided. This report begins with a presentation of the specific Method Quality Objectives (MQOs) that were identified for this project in the QAPP (Herrera 2005). Separate sections then describe field and laboratory quality control procedures that were during this project. Finally, data validation procedures and results are presented at the end of this report.

Method Quality Objectives

MQOs that were identified in the QAPP for this project (Herrera 2005) are presented herein. These MQOs identify targets with regard to the precision, bias, representativeness, completeness, and comparability of the collected data. Note that the term *reporting limit* in this section refers to the practical quantitation limit established by the laboratory, not the method detection limit.

- **Precision.** Precision was assessed using laboratory and field duplicates. Two levels of precision were evaluated for laboratory and field duplicates. For values that are greater than 5 times the reporting limit, the relative percent difference (RPD) of laboratory and field duplicates must be ≤20 percent. For values that are less than or equal to 5 times the reporting limit, duplicate values must be within ±2 times the reporting limit. In all cases, the RPD of duplicate samples was calculated using the following equation:

$$RPD = \frac{(C_1 - C_2) \times 100\%}{(C_1 + C_2) / 2}$$

where: RPD = relative percent difference
C_1 = larger of two values
C_2 = smaller of two values.

- **Bias.** Bias was assessed based on analyses of method blanks, matrix spikes, and control standards. The values for method blanks must not exceed the reporting limit. The percent recovery of matrix spikes must be between 75 and 125 percent. The percent recovery of control standards must be within 90 and 110 percent. Percent recovery for matrix spikes was calculated using the following equation:

$$\%R = \frac{(S - U) \times 100\%}{C_{sa}}$$

where: %R = percent recovery
S = measured concentration in spike sample
U = measured concentration in unspiked sample
C_{sa} = actual concentration of spike added.

If the analyte was not detected in the unspiked sample, then a value of zero was used in the equation.

Percent recovery for control standards was calculated using the following equation:

$$\%R = \frac{(M - T) \times 100\%}{T}$$

where: %R = percent recovery
M = measured value
T = true value.

- **Representativeness.** The sampling design was developed to provide samples that represent typical water quality conditions during storm flow conditions. Sample representativeness was ensured by employing consistent and standard sampling procedures.

- **Completeness.** A minimum of 95 percent of the samples submitted to the laboratory must be judged valid. An equipment checklist was used to prevent loss of data resulting from missing containers prior to embarking on field sampling trips.

- **Comparability.** Standard sampling procedures, analytical methods, units of measurement, and reporting limits were applied in this study to meet the goal of data comparability. The results were tabulated in standard spreadsheets to facilitate comparison with other study results.

Quality Control

To ensure the data quality objectives for this study are met, quality control procedures were identified in separate sections below for field and laboratory activities. The overall objective of these procedures was to ensure that data of a known and acceptable quality are collected for this project.

Field Quality Control Procedures

Quality control procedures that were implemented for field activities are described in the following subsections.

Field Notes

At each water quality monitoring station, the following information was recorded in a bound waterproof field notebook during storm sampling events:

- Sampling date
- Name of sampler
- Time of sample collection, measurement, or observation
- Station location
- Weather and flow conditions
- Number and type of samples collected
- Unusual conditions (e.g., oily sheen, odor, color, turbidity, discharges or spills, and land disturbances)
- Modifications of, or unusual, sampling procedures
- Any miscellaneous factors that might influence samples.

Decontamination

Components of the rainwater sampling devices (i.e., funnel and sample bottle) were decontaminated between storm events using the following procedure:

- Wash with phosphate-free detergent
- Rinse thoroughly with potable water
- Rinse with 10 percent reagent-grade hydrochloric acid to remove any adsorbed nutrients and metals
- Rinse thoroughly with deionized water.

Field Duplicates

Field duplicates for grab samples were collected by filling a second sample bottle immediately after the collection of the regular sample. One field duplicate was collected during the second,

third, and fourth sampling events for the SR520 Bridge. A field duplicate was also collected during the first sampling event for the Hood Canal Bridge. The station where the field duplicates were collected was chosen at random in advance of the storm event. All duplicate samples were submitted to the laboratory and labeled as separate (blind) samples. The resultant data from these samples was used to assess variation in the analytical results that is attributable to both environmental (natural), sampling, and analytical variability.

Sample Identification and Labeling

All sample containers were labeled with the following information using indelible ink:

- Station ID
- Date of sample collection (month/day/year)
- Time of sample collection (military format)
- Herrera project ID (i.e., WQSAMP520)
- Company/sampler initials.

Sample Containers and Preservation

Sample containers were obtained from the analytical laboratory for metals analyses. Spare sample containers were carried by the sampler in case of loss, breakage or possible contamination. Sample containers and preservation techniques (see Table 4) followed prescribed protocols for each analyte as identified in APHA et al. (1992) and U.S. EPA (1983, 1984).

Sample Collection

Water was collected as grab samples from each station during the selected storm events. The sample collection was conducted using a modified version of the "clean hands" and "dirty hands" protocol developed by the U.S. Environmental Protection Agency (U.S. EPA) (1996) for low-level detection of metals. The modified version of the protocol allowed sampling to be performed by one field technician as opposed to two.

Accordingly, the laboratory pre-cleaned bottles as required for the analytical method for metals. The laboratory then placed the metals bottles into two separate zip-lock bags for transport to the site. Prior to sample collection, the field technician donned a new set of gloves (i.e., clean, non talc gloves made of polyethylene, latex or vinyl) for each sequence of the clean or dirty hands operations that is required for proper implementation of the protocol. The sequence of clean and dirty hands operations that was used during sampling is described in detail as follows:

1. Dirty Hands (two sets of new gloves):

    a. open the cooler with sample bottles

    b. remove double-bagged sample bottle from cooler

c. unseal outer bag.

2. Clean Hands (remove outer set of gloves):

   a. unseal inner bag containing sample bottle

   b. remove bottle and unscrew cap

   c. rinse bottle three times in water to be sampled (if sample contains no preservative)

   d. fill sample bottle

   e. return sample bottle to inner bag

   f. reseal inner bag

   g. reseal outer bag

   h. return double-bagged sample to cooler.

Immediately after filling, sample bottles were placed in a cooler with ice and kept at 4°C during transport to the laboratory.

Chain-of-Custody Record

A chain-of custody record was maintained for each sample batch listing the sampling date and time, sample identification numbers, analytical parameters and methods, persons relinquishing and receiving custody, and dates and times of custody transfer.

Laboratory Quality Control Procedures

Quality control procedures that were implemented in the laboratory are described in the following subsections.

Method Blanks

Method blanks consisting of deionized distilled water were analyzed with every sample batch that was delivered to the laboratory. Blank values were presented in each laboratory report.

Control Standards

Control standards for each parameter were analyzed with every sample batch (i.e., one control standard was run for every four samples delivered to the laboratory). Percent recovery (see

formula in *Method Quality Objectives* section) for the control standards was presented in each laboratory report.

Matrix Spikes

Matrix spikes for each parameter were analyzed with every sample batch (i.e., one matrix spike will be run for every four samples delivered to the laboratory). Percent recovery (see formula in *Method Quality Objectives* section) for the matrix spikes was presented in each laboratory report.

Laboratory Duplicates

Laboratory duplicates for each parameter were analyzed for a randomly selected sample with every sample batch (i.e., one laboratory duplicate will be run for every four samples delivered to the laboratory). Data for batch samples (i.e., samples from other projects analyzed with samples from this project) were considered acceptable as long as duplicates were analyzed at a frequency of at least 5 percent. The relative percent difference (see formula in *Method Quality Objectives* section) of the duplicate results was presented in each laboratory report.

Date Review, Verification, and Validation

Data were reviewed and validated within 7 days of receiving the results from the field or laboratory. This review was performed to ensure that all data are consistent, correct and complete, and that all required quality control information was provided. Specific quality control elements for the data were also examined to determine if the MQOs for the project were met. Results from these data validation reviews were summarized in quality assurance worksheets that were prepared for each sample batch. Values associated with minor quality control problems were considered estimates and assigned *J* qualifiers. Values associated with major quality control problems were rejected and qualified *R*. These estimated values were used for evaluation purposes, while rejected values were not used. The following sections describe in detail the data validation procedures for these quality control elements:

- Completeness
- Methodology
- Holding times
- Blanks
- Reporting limits
- Duplicates
- Matrix spikes
- Control standards.

Completeness

Completeness was assessed by comparing valid sample data with this quality assurance project plan and the chain-of-custody records. Completeness was calculated by dividing the number of valid values by the total number of values. Samples were re-analyzed or re-collected if completeness was less than 95 percent.

Methodology

Analytical procedures followed U.S. EPA approved methods (APHA et al. 1992; U.S. EPA 1983, 1984). Field procedures followed the methodologies described in the project QAPP (Herrera 2005). Any deviations from these procedures that were deemed unacceptable resulted in rejected values (R).

Holding Times

Analysis dates were reported by the laboratory. Holding times were assessed by comparing analytical dates and times to sample collection dates and times. Data from samples that exceeded the maximum holding time by less than 48 hours will be considered estimates (J). Data from samples that exceeded the maximum holding times by more than 48 hours were rejected values (R). Holding times for each analytical parameter in this study are summarized in Table 4.

Blanks

Blank values were compared to the MQOs that have been identified for this project. Sample values that were less than 5 times a detected method blank value were considered estimates (J).

Reporting Limits

Reporting limits were presented in each laboratory report. If proposed reporting limits were not met by the laboratory, the laboratory was requested to reanalyze the samples and/or revise the method, if time permits. Proposed reporting limits for this project are summarized in Table 4.

Duplicates

Duplicate results exceeding the MQOs for this project were noted in the quality assurance worksheets, and associated values were flagged as estimates (J). If the objectives were severely exceeded (e.g., more than twice the objective), then associated values were rejected (R).

Matrix Spikes

Matrix spike results exceeding the MQOs for this project were noted in the quality assurance worksheets, and associated values were flagged as estimates (J). However, if the percent recovery exceeded 125 and a value was less than the reporting limit, the result was not flagged as an estimate. Nondetected values were rejected (R) if percent recovery was less than 30 percent.

Control Standards

Control standard results exceeding the MQOs for this project were noted in the quality assurance worksheets, and associated values were flagged as estimates (J). If the objectives were severely exceeded (e.g., more than twice the objective), then associated values were rejected (R).

Data Validation Results

The Herrera quality assurance officer performed an independent review of the quality control data from each sampling event in accordance with the MQOs that were identified in the project QAPP (Herrera 2005). Data quality issues that were identified through this review are as follows:

- Dissolved zinc and copper concentrations measured on the SR520 Bridge during the March 19 and 26 sampling events were flagged as estimates (J) because the associated samples were not filtered within the required 12. Samples from the March 19 and 26 sampling event were filtered within 23 and 24 hours of collection, respectively.

- Dissolved zinc and copper concentrations measured on the Hood Canal Bridge during the March 19 and April 7 sampling events were flagged as estimates (J) because the associated samples were not filtered within the required 12. Samples from the March 19 and 26 sampling event were filtered within 72 and 154 hours of collection, respectively.

- Dissolved zinc and copper concentrations measured on the I-90 during the March 26 sampling events were flagged as estimates (J) because the associated samples were not filtered within the required 12. Samples from this sampling event were filtered within 25 hours of collection,

APPENDIX B

Water Quality Database

Table B1. Water quality data collected during sampling on the SR520 Bridge, I-90 Bridge, and Hood Canal Bridge; Winter 2005.

Bridge	Station Type	Sample Type	Station ID	Date	Time	Total Copper (mg/L)	Total Zinc (mg/L	Dissolved Copper (mg/L)	Dissolved Zinc (mg/L)
SR520	Deck		DE-Drawspan	3/19/2005	15:34	0.027	0.334	0.023 J	0.263 J
SR520	Deck		DE-S4	3/19/2005	14:41	0.071	0.225	0.064 J	0.142 J
SR520	Deck		DE-S9	3/19/2005	15:12	0.094	0.296	0.045 J	0.121 J
SR520	Short Downspout		DS-N4	3/19/2005	14:20	0.057	0.214	0.055 J	0.171 J
SR520	Short Downspout		DS-N9	3/19/2005	15:06	0.041	0.138	0.038 J	0.109 J
SR520	Short Downspout		DS-S4	3/19/2005	14:31	0.068	0.206	0.057 J	0.154 J
SR520	Short Downspout		DS-S9	3/19/2005	15:00	0.077	0.239	0.052 J	0.126 J
SR520	Long Downspout		DS-N1	3/19/2005	13:56	0.081	0.988	0.080 J	0.855 J
SR520	Long Downspout		DS-S1	3/19/2005	14:05	0.048	6.520	0.044 J	5.430 J
SR520	Rainwater		Rainwater	3/19/2005	16:05	0.003 U	0.011	0.003 UJ	0.011 J
SR520	Deck		DE-Drawspan	3/24/2005	2:45	0.033	0.166	0.008	0.027
SR520	Deck		DE-S4	3/24/2005	1:58	0.024	0.154	0.012	0.095
SR520	Deck		DE-S9	3/24/2005	2:30	0.017	0.127	0.008	0.078
SR520	Short Downspout		DS-N4	3/24/2005	1:55	0.045	0.251	0.017	0.166
SR520	Short Downspout		DS-N9	3/24/2005	2:25	0.043	0.173	0.010	0.076
SR520	Short Downspout		DS-S4	3/24/2005	1:50	0.011	0.069	0.007	0.047
SR520	Short Downspout		DS-S9	3/24/2005	2:15	0.010	0.103	0.004	0.036
SR520	Long Downspout		DS-N1	3/24/2005	1:40	0.010	0.204	0.006	0.121
SR520	Long Downspout	Duplicate	DS-N1	3/24/2005	1:40	0.045	0.404	0.010	0.245
SR520	Long Downspout		DS-S1	3/24/2005	1:30	0.030	5.15	0.015	1.6
SR520	Truck Wash		Truck Wash Water	3/24/2005	3:00	0.011	0.022	0.00010 U	0.023
SR520	Deck		DE-Drawspan	3/26/2005	8:40	0.011	0.064	0.008 J	0.050 J
SR520	Deck		DE-S4	3/26/2005	9:14	0.027	0.098	0.021 J	0.065 J
SR520	Deck		DE-S9	3/26/2005	9:35	0.078	0.206	0.027 J	0.101 J
SR520	Short Downspout		DS-N4	3/26/2005	9:05	0.017	0.077	0.015 J	0.073 J
SR520	Short Downspout		DS-N9	3/26/2005	9:25	0.027	0.115	0.014 J	0.080 J
SR520	Short Downspout	Duplicate	DS-N9	3/26/2005	9:25	0.018	0.086	0.014 J	0.084 J
SR520	Short Downspout		DS-S4	3/26/2005	9:09	0.029	0.109	0.019 J	0.090 J
SR520	Short Downspout		DS-S9	3/26/2005	9:30	0.060	0.193	0.023 J	0.075 J
SR520	Long Downspout		DS-N1	3/26/2005	8:50	0.013	0.487	0.012 J	0.459 J
SR520	Long Downspout		DS-S1	3/26/2005	8:55	0.014	0.866	0.014 J	0.876 J
SR520	Rainwater		Rainwater	3/26/2005	10:10	0.0010 U	0.008	0.0010 UJ	0.007 J
SR520	Deck		DE-Drawspan	4/1/2005	5:20	0.0122	0.130	0.0049	0.095
SR520	Deck		DE-S4	4/1/2005	6:15	0.0441	0.177	0.0154	0.072
SR520	Deck		DE-S9	4/1/2005	6:45	0.0496	0.288	0.0207	0.108
SR520	Short Downspout		DS-N4	4/1/2005	5:50	0.0235	0.137	0.0086	0.105
SR520	Short Downspout	Duplicate	DS-N4	4/1/2005	5:50	0.0246	0.140	0.0083	0.082
SR520	Short Downspout		DS-N9	4/1/2005	6:30	0.0164	0.220	0.0094	0.211

Table B1. Water quality data collected during sampling on the SR520 Bridge, I-90 Bridge, and Hood Canal Bridge; Winter 2005.

Bridge	Station Type	Sample Type	Station ID	Date	Time	Total Copper (mg/L)	Total Zinc (mg/L	Dissolved Copper (mg/L)	Dissolved Zinc (mg/L)
SR520	Short Downspout		DS-S4	4/1/2005	6:00	0.0192	0.409	0.0142	0.420
SR520	Short Downspout		DS-S9	4/1/2005	6:35	0.0311	0.161	0.0196	0.145
SR520	Long Downspout		DS-N1	4/1/2005	5:30	0.0201	0.765	0.0091	0.739
SR520	Long Downspout		DS-N20	4/1/2005	6:55	0.0225	1.03	0.0119	0.875
SR520	Long Downspout		DS-S1	4/1/2005	5:40	0.0202	8.070	0.0097	7.31
SR520	Long Downspout		DS-S20	4/1/2005	7:00	0.0219	1.65	0.0172	1.610
SR520	Rainwater		Rainwater	4/1/2005	7:20	--	--	0.0010 U	0.018
I90	Deck		HH-DE-1	3/26/2005	8:00	0.011	0.019	0.008 J	0.009 J
I90	Deck		LUM-DE-1	3/26/2005	8:38	0.019	0.064	0.009 J	0.019 J
I90	Long Downspout		HH-DS-1	3/26/2005	8:26	0.026	0.095	0.007 J	0.019 J
I90	Long Downspout		LUM-DS-1	3/26/2005	8:19	0.013	0.110	0.008 J	0.071 J
Hood Canal	Deck		West Drain	3/19/2005	2:15	0.0063	0.045	0.0042 J	0.020 J
Hood Canal	Short Downspout		East Downspout - 10 foot	3/19/2005	2:30	0.0158	0.124	0.0107 J	0.099 J
Hood Canal	Short Downspout	Duplicate	East Downspout - 10 foot	3/19/2005	2:40	0.0153	0.109	0.0103 J	0.097 J
Hood Canal	Deck		West Drain	4/7/2005	1:45	0.0091	0.022	0.0051 J	0.006 J
Hood Canal	Short Downspout		East Downspout - 10 foot	4/7/2005	1:40	0.0050	0.105	0.0023 J	0.088 J
Hood Canal	Long Downspout		East Downspout - 40 foot	4/7/2005	1:30	0.0061	0.127	0.0039 J	0.099 J

U: Analyte not detected at specified detection limit.
J: Estimated value from quality assurance review

APPENDIX C

Laboratory Reports, Chain-of-Custody Records, and Quality Assurance Worksheets for Collected Stormwater Quality Data

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**HER071-05**	**PAGE 1**	
REPORT DATE:	**03/31/05**		
DATE SAMPLED:	**03/19/05**	**DATE RECEIVED:**	**03/20/05**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

CASE NARRATIVE

Ten water samples were received by the laboratory in good condition. Samples for total recoverable metals analysis were digested according to EPA procedures. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

	TOTAL METALS		DISSOLVED METALS	
SAMPLE ID	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)
DS-N1	0.081	0.988	0.080	0.855
DS-S1	0.048	6.520	0.044	5.43
DS-N4	0.057	0.214	0.055	0.171
DS-S4	0.068	0.206	0.057	0.154
DE-S4	0.071	0.225	0.064	0.142
DS-S9	0.077	0.239	0.052	0.126
DS-N9	0.041	0.138	0.038	0.109
DE-S9	0.094	0.296	0.045	0.121
DE-DRAWSPAN	0.027	0.334	0.023	0.263
RAINWATER	<0.003	0.011	<0.003	0.011

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: HER071-05 **PAGE 2**

REPORT DATE: 03/31/05

DATE SAMPLED: 03/19/05 **DATE RECEIVED:** 03/20/05

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

QA/QC DATA

	TOTAL METALS		DISSOLVED	
QC PARAMETER	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)
METHOD	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7
DATE PREPARED	03/23/05	03/23/05	03/20/05	03/20/05
DATE ANALYZED	03/30/05	03/30/05	03/25/05	03/25/05
DETECTION LIMIT	0.003	0.005	0.003	0.005
DUPLICATE				
SAMPLE ID	BATCH	BATCH	DE-S9	DE-S9
ORIGINAL	<0.003	0.021	0.045	0.121
DUPLICATE	<0.003	0.020	0.047	0.125
RPD	NC	4.88%	4.35%	3.25%
SPIKE SAMPLE				
SAMPLE ID	BATCH	BATCH	DE-S9	DE-S9
ORIGINAL	<0.003	0.021	0.045	0.121
SPIKED SAMPLE	0.953	0.986	1.16	1.09
SPIKE ADDED	1.00	1.00	1.00	1.00
% RECOVERY	95.30%	96.50%	111.50%	96.90%
QC CHECK (mg/l)				
	0.99	0.935	1.02	0.919
TRUE	1.00	1.00	1.00	1.00
% RECOVERY	99.00%	93.50%	102.40%	91.90%
PREP BLANK	<0.003	<0.005	<0.003	<0.005

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

Submitted By:

Steven Lazoff
Laboratory Director

HERC071-05

Aquatic Research Incorporated

3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

CLIENT: John Lenth

SAMPLING DATE: 3/19/05

SAMPLERS: John Lenth

SHEET _____ OF _____

PROJECT ID: _____

CASE FILE NO.: _____

DATA RECORDED BY: _____

SAMPLE INFORMATION

PARAMETERS

SAMPLE ID	DATE/TIME COLLECTED	Copper - Dissolved	Copper - Total	Zinc - Dissolved	Zinc - Total	BOTT #	NOTES
DS-N1	3/19/05 13:56	X	X	X	X		
DS-S1	3/19/05 14:05	X	X	X	X		
DS-N4	3/19/05 14:20	X	X	X	X		
DS-S4	3/19/05 14:31	X	X	X	X		
DE-S4	3/19/05 14:41	X	X	X	X		
DS-S9	3/19/05 15:00	X	X	X	X		
DS-N9	3/19/05 15:06	X	X	X	X		
DE-S9	3/19/05 15:12	X	X	X	X		
DE - Drawdown	3/19/05 15:34	X	X	X	X		
Rainwater	3/19/05 16:05	X	X	X	X		

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	John Lenth	3/20/05 11:25	Steve Lazoff	3/20/05 1125
Signature				
Affiliation	HEC		AR	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.): Metals Filtered 3/20/05 13:00 SL

1 hr. QUR

HERRERA ENVIRONMENTAL CONSULTANTS

Data Quality Assurance Worksheet

By John Lenth
Date 4/28/05 Page ___ of ___
Checked initials ___
date ___

Project Name/No./Client: 520BRIDGELWQ / 04-02916-007 / WSDOT
Laboratory/Parameters: ART / Total & Dissolved Cu, Zn
Sample Date/Sample ID: 3-19-05 / SR520 Bridge

Parameter	Completeness/ Methodology	Holding Times	Blanks/ Detection Limits	Matrix Spikes/ Surrogate Recoveries	Lab Duplicates	Field Duplicates	Lab Control Samples	Instrument Calibration/ Performance	ACTION
Total Copper	Ok.	Ok.	<0.003 0.003 Ok.	95.0% Ok.	NC	NA	99.0% Ok.	Ok.	None
Total Zinc	Ok.	ok.	<0.005 0.005 Ok.	96.5% Ok.	<2 times the detection limit Ok.	NA	93.5% Ok.	Ok.	None
Dissolved Copper	Ok.	23 hours elapsed before samples were filtered. Monitoring plan specifies filtration within 12-hours	<0.003 0.003 Ok.	111.5% Ok.	4.35% Ok.	NA	102.4% ok.	Ok.	Values flagged as estimates
Dissolved Zinc	Ok.	23 hours elapsed before samples were filtered. Monitoring plan specifies filtration within 12-hours	<0.005 0.005 Ok.	96.9% Ok.	3.25% Ok.	NA	91.9% Ok.	Ok.	Values flagged as estimates

NC: Not calculable due to one or more values below the detection limit.
NA: Not applicable.

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	MIS009-73	PAGE 1	
REPORT DATE:	04/11/05		
DATE SAMPLED:	03/19/05	DATE RECEIVED:	03/22/05

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

CASE NARRATIVE

Three water samples were received by the laboratory in good condition. Samples for total recoverable metals analysis were digested according to EPA procedures. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

	TOTAL METALS		DISSOLVED METALS	
SAMPLE ID	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)
HOOD CANAL-WEST DRAIN	0.0063	0.045	0.0042	0.020
HOOD CANAL- EAST DOWNSPOUT	0.0158	0.124	0.0107	0.099
HOOD CANAL- EAST DOWNSPOUT2	0.0153	0.109	0.0103	0.097

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS009-73**	**PAGE 2**	
REPORT DATE:	**04/11/05**		
DATE SAMPLED:	**03/19/05**	**DATE RECEIVED:**	**03/22/05**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

QA/QC DATA

	TOTAL METALS		DISSOLVED	
QC PARAMETER	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)
METHOD	EPA 220.2	EPA 200.7	EPA 220.2	EPA 200.7
DATE PREPARED	03/23/05	03/23/05	03/19/05	03/19/05
DATE ANALYZED	04/07/05	04/07/05	04/07/05	04/07/05
DETECTION LIMIT	0.0010	0.005	0.0010	0.005
DUPLICATE				
SAMPLE ID	BATCH	BATCH	HOOD CANAL-WEST DRAIN	HOOD CANAL-WEST DRAIN
ORIGINAL	<0.0010	0.008	0.0042	0.020
DUPLICATE	<0.0010	0.008	0.0041	0.020
RPD	NC	5.13%	2.41%	0.00%
SPIKE SAMPLE				
SAMPLE ID	BATCH	BATCH	HOOD CANAL-WEST DRAIN	HOOD CANAL-WEST DRAIN
ORIGINAL	<0.0010	0.008	0.0042	0.020
SPIKED SAMPLE	0.0135	1.11	0.0161	1.14
SPIKE ADDED	0.0125	1.00	0.0125	1.00
% RECOVERY	108.00%	110.20%	95.20%	112.00%
QC CHECK (mg/l)				
	0.0231	1.02	0.0231	1.02
TRUE	0.0250	1.00	0.0250	1.00
% RECOVERY	92.20%	101.80%	92.20%	101.80%
PREP BLANK	<0.0010	<0.005	<0.0010	<0.005

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

Submitted By:

Steven Lazoff
Laboratory Director

M1S009-73

Aquatic Research Incorporated

3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

SHEET 1 OF 1

CLIENT: WSDOT

SAMPLING DATE: 3/19/05

SAMPLERS: Jana Crawford (360-570-6649)

PROJECT ID:

CASE FILE NO.:

DATA RECORDED BY:

SAMPLE INFORMATION

SAMPLE ID	DATE/TIME COLLECTED	PARAMETERS: Total & Dissolved Zinc & Copper	BOTT #	NOTES
Hood Canal - West Drain	3/19/05 2:15	X		
Hood Canal - East Downspout	3/19/05 2:30	X		
Hood Canal - East Downspout 2	3/19/05 2:40	X		

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	Jana Crawford	3/21/05 7:40 AM	S. Nicolson	3/22/05
Signature	Jana Crawford			1400
Affiliation	WSDOT		ARI	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.): Results and bill for analysis should be sent to John Lenth @ Herrera Environmental Consultants 2200 Sixth Ave, Ste. 1100 Seattle, WA 98121 Phone: (206) 441-9080

HERRERA ENVIRONMENTAL CONSULTANTS

Data Quality Assurance Worksheet

By John Lenth
Date 4/28/05 Page 1 of 1
Checked initials
date

Project Name/No./Client: 520BRIDGEWQ/04-02916-007/WSDOT
Laboratory/Parameters: ARI / Total & Dissolv Cu, Zn
Sample Date/Sample ID: 3-19-05 / Hood Canal Bridge

Parameter	Completeness/ Methodology	Holding Times	Blanks/ Detection Limits	Matrix Spikes/ Surrogate Recoveries	Lab Duplicates	Field Duplicates	Lab Control Samples	Instrument Calibration/ Performance	ACTION
Total Copper	O.K.	O.K.	<0.0010 0.0010 O.K.	108.0% O.K.	NC	NA	92.2% O.K.	O.K.	None
Total Zinc	O.K.	O.K.	<0.005 0.005 O.K.	110.2% O.K.	< 2 times the detection limit O.K.	NA	101.8% O.K.	O.K.	None
Dissolved Copper	O.K.	72-hours elapsed before samples were filtered. Monitoring plan specifies filteration within 12-hours	<0.0010 0.0010 O.K.	95.2% O.K.	< 2 times the detection limit O.K.	NA	92.2% O.K.	O.K.	Values flagged as estimates
Dissolved Zinc	O.K.	72-hours elapsed before samples were filtered Monitoring plan specifies filteration within 12-hours	<0.005 0.005 O.K.	112.0% O.K.	< 2 times the detection limit O.K.	NA	101.8% O.K.	O.K.	Values flagged as estimates

NC: Not calculable due to one or more values being below detection limit.
NA: Not applicable.

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**HER071-07**	**PAGE 1**	
REPORT DATE:	**04/11/05**		
DATE SAMPLED:	**03/24/05**	**DATE RECEIVED:**	**03/24/05**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

CASE NARRATIVE

Eleven water samples were received by the laboratory in good condition. Samples for total recoverable metals analysis were digested according to EPA procedures. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

	TOTAL METALS		DISSOLVED METALS	
SAMPLE ID	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)
DS-N1	0.010	0.204	0.006	0.121
DS-S1	0.030	5.15	0.015	1.60
DS-N4	0.045	0.251	0.017	0.166
DS-S4	0.011	0.069	0.007	0.047
DE-S4	0.024	0.154	0.012	0.095
DS-S9	0.010	0.103	0.004	0.036
DS-N9	0.043	0.173	0.010	0.076
DE-S9	0.017	0.127	0.008	0.078
DE-DRAWSPAN	0.033	0.166	0.008	0.027
TRUCK WASH WATER	0.0011	0.022	<0.0010	0.023
DUPLICATE	0.045	0.404	0.010	0.245

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**HER071-07**	**PAGE 2**	
REPORT DATE:	**04/11/05**		
DATE SAMPLED:	**03/24/05**	**DATE RECEIVED:**	**03/24/05**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

QA/QC DATA

	TOTAL METALS		DISSOLVED	
QC PARAMETER	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)
METHOD	EPA 200.7,220.2	EPA 200.7	EPA 200.7,220.2	EPA 200.7
DATE PREPARED	04/04/05	04/04/05	03/24/05	03/24/05
DATE ANALYZED	04/06,11/05	04/07/05	04/06,11/05	04/06/05
DETECTION LIMIT	0.0010	0.005	0.0010	0.005
DUPLICATE				
SAMPLE ID	DE-DRAWSPAN	DE-DRAWSPAN	DE-S9	DE-S9
ORIGINAL	0.033	0.166	0.008	0.078
DUPLICATE	0.032	0.167	0.008	0.082
RPD	3.08%	0.60%	0.00%	5.00%
SPIKE SAMPLE				
SAMPLE ID	DE-DRAWSPAN	DE-DRAWSPAN	DE-S9	DE-S9
ORIGINAL	0.033	0.166	0.008	0.078
SPIKED SAMPLE	1.15	1.25	1.14	1.16
SPIKE ADDED	1.00	1.00	1.00	1.00
% RECOVERY	111.60%	108.00%	113.20%	107.80%
QC CHECK (mg/l)				
	1.03	1.02	1.10	1.01
TRUE	1.00	1.00	1.00	1.00
% RECOVERY	102.50%	101.90%	110.00%	100.90%
PREP BLANK	<0.0010	<0.005	<0.0010	<0.005

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

Submitted By:

Steven Lazoff
Laboratory Director

HERO71-07

Aquatic Research Incorporated
3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

CLIENT: DAN BENNETT
SAMPLING DATE: 3/24/05
SAMPLERS: DAN BENNETT

SHEET 1 OF 1
PROJECT ID:
CASE FILE NO.:
DATA RECORDED BY:

SAMPLE INFORMATION

PARAMETERS

SAMPLE ID	DATE/TIME COLLECTED	Copper-dissolved	Copper-Total	Zinc-dissolved	Zinc-Total	BOTT #	NOTES
DS-N1	3/24/05 13:40	X	X	X	X	1	
DS-S1	13:30						
DS-N4	13:55						
DS-S4	13:50						
DE-S4	13:58						
DS S9	14:15						
DS N9	14:25						
DE S9	14:30						
DE-DRAWSPAN	14:45						
TRUCK WASH WATER	15:00						
Duplicate	✓ X						

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	DAN BENNETT	3/24/05	S-NELSON	3/24/05
Signature		11:30		1130
Affiliation	HERRERA		ARI	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

HERRERA ENVIRONMENTAL CONSULTANTS

Data Quality Assurance Worksheet

By John Leuth
Date 3-29-05 Page ___ of ___
Checked initials ___
date ___

Project Name/No./Client: 52C BRIDGEWQ/04-02916007/WSDOT
Laboratory/Parameters: ARI / Total & Dissolved Cu, Zn
Sample Date/Sample ID: 3-24-05 / SR 520 Bridge

Parameter	Completeness/ Methodology	Holding Times	Blanks/ Detection Limits	Matrix Spikes/ Surrogate Recoveries	Lab Duplicates	Field Duplicates*	Lab Control Samples	Instrument Calibration/ Performance	ACTION
Total Copper	Ok.	O.K.	<0.0010 0.0010	111.7% ok.	3.08% Ok.	127.3%	102.5% O.K.	O.K.	None
Total Zinc	Ok.	Ok.	<0.005 0.005	101.9% ok.	0.60% Ok.	65.8%	101.9% O.K.	Ok.	None
Dissolved Copper	Ok.	Ok.	<0.0010 0.0010	113.2% Ok.	0.00% Ok.	50.0%	110.0% O.K.	Ok.	None
Dissolved Zinc	Ok.	Ok.	<0.005 0.005	107.8% ok.	5.00% ok.	67.8%	100.9% O.K.	Ok.	None

* Samples collected during bridge flushing operations. Field variability is expected to be very high.

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**HER071-09**		**PAGE 1**
REPORT DATE:	**4/11/2005 REVISED 04/29/05**		
DATE SAMPLED:	**03/26/05**	**DATE RECEIVED:**	**03/27/05**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

CASE NARRATIVE

Eleven water samples were received by the laboratory in good condition. Samples for total recoverable metals analysis were digested according to EPA procedures. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

	TOTAL METALS		DISSOLVED METALS	
SAMPLE ID	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)
DS-N1	0.013	0.487	0.012	0.459
DS-S1	0.014	0.866	0.014	0.876
DS-N4	0.017	0.077	0.015	0.073
DS-S4	0.029	0.109	0.019	0.090
DE-S4	0.027	0.098	0.021	0.065
DS-N9	0.027	0.115	0.014	0.080
DS-S9	0.060	0.193	0.023	0.075
DE-S9	0.078	0.206	0.027	0.101
DE-DRAWSPAN	0.011	0.064	0.008	0.050
RAINWATER	<0.0010	0.008	<0.0010	0.007
FIELD DUPLICATE	0.018	0.086	0.014	0.084

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: HER071-09 **PAGE 2**

REPORT DATE: 4/11/2005 REVISED 04/29/05

DATE SAMPLED: 03/26/05 **DATE RECEIVED:** 03/27/05

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

QA/QC DATA

	TOTAL METALS		DISSOLVED	
QC PARAMETER	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)
METHOD	EPA 200.7,220.2	EPA 200.7	EPA 200.7,220.2	EPA 200.7
DATE PREPARED	04/05/05	04/05/05	03/27/05	03/27/05
DATE ANALYZED	04/06,11/05	04/08/05	04/06,11/05	04/06/05
DETECTION LIMIT	0.0010	0.005	0.0010	0.005
DUPLICATE				
SAMPLE ID	DE-DRAWSPAN	DE-DRAWSPAN	BATCH	BATCH
ORIGINAL	0.011	0.064	0.003	0.389
DUPLICATE	0.012	0.069	0.003	0.385
RPD	8.70%	7.52%	0.00%	1.03%
SPIKE SAMPLE				
SAMPLE ID	DE-DRAWSPAN	DE-DRAWSPAN	BATCH	BATCH
ORIGINAL	0.011	0.064	0.003	0.389
SPIKED SAMPLE	1.14	1.14	1.12	1.47
SPIKE ADDED	1.00	1.00	1.00	1.00
% RECOVERY	112.90%	107.60%	111.70%	108.10%
QC CHECK (mg/l)				
	1.02	1.02	1.06	0.994
TRUE	1.00	1.00	1.00	1.00
% RECOVERY	102.00%	101.80%	105.70%	99.40%
PREP BLANK	<0.0010	0.005	<0.0010	<0.005

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

Submitted By:

Steven Lazoff

Laboratory Director

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**HER071-09**	**PAGE 1**	
REPORT DATE:	**04/11/05**		
DATE SAMPLED:	**03/26/05**	**DATE RECEIVED:**	**03/27/05**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

CASE NARRATIVE

Eleven water samples were received by the laboratory in good condition. Samples for total recoverable metals analysis were digested according to EPA procedures. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

	TOTAL METALS		DISSOLVED METALS	
SAMPLE ID	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)
DS-N1	0.013	0.487	0.012	0.459
DS-S1	0.014	0.866	0.014	0.876
DS-N4	0.017	0.077	0.015	0.073
DS-S4	0.029	0.109	0.019	0.090
DE-S4	0.027	0.098	0.021	0.065
DS-N9	0.027	0.115	0.014	0.080
DS-S9	0.060	0.193	0.023	0.075
DE-S9	0.078	0.206	0.027	0.101
DE-DRAWSPAN	0.011	0.064	0.008	0.050
RAINWATER	<0.0010	0.008	<0.0010	0.033
FIELD DUPLICATE	0.018	0.086	0.014	0.084

Reanalyzed

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**HER071-09**	**PAGE 2**	
REPORT DATE:	**04/11/05**		
DATE SAMPLED:	**03/26/05**	**DATE RECEIVED:**	**03/27/05**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

QA/QC DATA

	TOTAL METALS		DISSOLVED	
QC PARAMETER	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)
METHOD	EPA 200.7,220.2	EPA 200.7	EPA 200.7,220.2	EPA 200.7
DATE PREPARED	04/05/05	04/05/05	03/27/05	03/27/05
DATE ANALYZED	04/06,11/05	04/08/05	04/06,11/05	04/06/05
DETECTION LIMIT	0.0010	0.005	0.0010	0.005
DUPLICATE				
SAMPLE ID	DE-DRAWSPAN	DE-DRAWSPAN	BATCH	BATCH
ORIGINAL	0.011	0.064	0.003	0.389
DUPLICATE	0.012	0.069	0.003	0.385
RPD	8.70%	7.52%	0.00%	1.03%
SPIKE SAMPLE				
SAMPLE ID	DE-DRAWSPAN	DE-DRAWSPAN	BATCH	BATCH
ORIGINAL	0.011	0.064	0.003	0.389
SPIKED SAMPLE	1.14	1.14	1.12	1.47
SPIKE ADDED	1.00	1.00	1.00	1.00
% RECOVERY	112.90%	107.60%	111.70%	108.10%
QC CHECK (mg/l)				
	1.02	1.02	1.06	0.994
TRUE	1.00	1.00	1.00	1.00
% RECOVERY	102.00%	101.80%	105.70%	99.40%
PREP BLANK	<0.0010	0.005	<0.0010	<0.005

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

Submitted By:

Steven Lazoff
Laboratory Director

Her071-09

HERRERA ENVIRONMENTAL CONSULTANTS
200 Sixth Avenue, Suite 1100
Seattle, Washington 98121
(206) 441-9080
FAX (206) 441-9108

CHAIN OF CUSTODY RECORD

PROJECT NAME:	PROJECT NUMBER:	CLIENT:
SR520 Bridge	04-2916-007	Herrera Environmental Consultants
REPORT TO: J. Lenth		COPY TO:
SAMPLED BY: Dan Bennett		DELIVERY METHOD: Hand
LABORATORY: Aquatic Research Inc.	REQUESTED COMPLETION DATE: 30 days	TOTAL # OF CONTAINERS: 11

LAB USE:

SAMPLE ID:	DATE:	TIME:	SAMPLE DESCRIPTION	# OF CONTAINERS:	ANALYSES REQUESTED: dissolved copper	Total copper	dissolved zinc	Total zinc
DS-N1	3/26/05	8:50	Storm flow	1	x	x	x	x
DS-S1	3/26/05	8:55	Storm flow	1	x	x	x	x
DS-N4	3/26/05	9:05	Storm flow	1	x	x	x	x
DS-S4	3/26/05	9:09	Storm flow	1	x	x	x	x
DE-S4	3/26/05	9:14	Storm flow	1	x	x	x	x
DS-N9	3/26/05	9:25	Storm flow	1	x	x	x	x
DS-S9	3/26/05	9:30	Storm flow	1	x	x	x	x
DE-S9	3/26/05	9:35	Storm flow	1	x	x	x	x
DE-DRAWSPAN	3/26/05	8:40	Storm flow	1	x	x	x	x
RAINWATER	3/26/05	10:10	Storm flow	1	x	x	x	x
Field Duplicate	3/26/05	--	Storm flow	1	x	x	x	x

REMARKS: Please composite the three 1-liter bottles berfore analysis. TPH and Fecal coliform bottles were filled 1/3 of the way in each of three rounds from 11:05 to 13:05.

Metals Filtered 3/27/05 SL

RELINQUISHED BY (NAME/CO.):	SIGNATURE:	DATE/TIME:	RECEIVED BY (NAME/CO.):	SIGNATURE:	DATE/TIME:
Dan Bennett (Herrera Environmental)		3/26/05	Rob Zisette		3/27/05 0910
RELINQUISHED BY (NAME/CO.): Rob Zisette	SIGNATURE:	DATE/TIME: 3/27/05 0930	RECEIVED BY (NAME/CO.): Steven Lazoff	SIGNATURE:	DATE/TIME: 3/27/05 0930

Data Quality Assurance Worksheet

HERRERA ENVIRONMENTAL CONSULTANTS

By: John Lenth
Date: 4-29-05 Page ___ of ___
Checked initials: ___
date: ___

Project Name/No./Client: 520BRIDGEWQ/04-02916-007/WSDOT
Laboratory/Parameters: ARI / Total & Dissolved Cu, Zn
Sample Date/Sample ID: 3-20-05 / SR 520 Bridge

Parameter	Completeness/ Methodology	Holding Times	Blanks/ Detection Limits	Matrix Spikes/ Surrogate Recoveries	Lab Duplicates	Field Duplicates	Lab Control Samples	Instrument Calibration/ Performance	ACTION
Total Copper	O.K.	O.K.	<0.0010 0.0010 O.K.	112.9% O.K.	8.70% OK.	40.0%	102.0% O.K.	O.K.	None
Total Zinc	O.K.	O.K.	<0.005 0.005 O.K.	107.6% O.K.	7.52% O.K.	28.9%	101.8% O.K.	O.K.	None
Dissolved Copper	O.K.	24 hours elapsed before samples were filtered. Monitoring Plan specifies filtration within 12-hours	<0.0010 0.0010 O.K.	117.7% O.K.	<2 times the detection limit O.K.	@.0% O.K.	105.7% O.K.	O.K.	Values flagged as estimates
Dissolved Zinc	O.K.	24 hours elapsed before samples were filtered Monitoring Plan specifies filtration within 12-hours	<0.005 0.005 O.K.	108.1% O.K.	1.05% O.K.	4.88% O.K.	99.4% O.K.	O.K.	Values flagged as estimates

Notes: Dissolved zinc concentration for rainwater sample is higher than total zinc concentration. Samples reanalyzed by lab.

file: DATAQA3.XLS

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**HER071-08**	**PAGE 1**	
REPORT DATE:	**04/11/05**		
DATE SAMPLED:	**03/26/05**	**DATE RECEIVED:**	**03/27/05**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

CASE NARRATIVE

Four water samples were received by the laboratory in good condition. Samples for total recoverable metals analysis were digested according to EPA procedures. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

	TOTAL METALS		DISSOLVED METALS	
SAMPLE ID	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)
HH-DE-1	0.011	0.019	0.008	0.009
LUM-DS-1	0.013	0.110	0.008	0.071
HH-DS-1	0.026	0.095	0.007	0.019
LUM-DE-1	0.019	0.064	0.009	0.019

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: HER071-08 **PAGE 2**

REPORT DATE: 04/11/05

DATE SAMPLED: 03/26/05 **DATE RECEIVED:** 03/27/05

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

QA/QC DATA

	TOTAL METALS		DISSOLVED	
QC PARAMETER	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)
METHOD	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7
DATE PREPARED	04/05/05	04/05/05	03/27/05	03/27/05
DATE ANALYZED	04/08/05	04/08/05	04/06/05	04/06/05
DETECTION LIMIT	0.003	0.005	0.003	0.005
DUPLICATE				
SAMPLE ID	BATCH	BATCH	BATCH	BATCH
ORIGINAL	0.011	0.064	0.003	0.389
DUPLICATE	0.012	0.069	0.003	0.385
RPD	8.70%	7.52%	0.00%	1.03%
SPIKE SAMPLE				
SAMPLE ID	BATCH	BATCH	BATCH	BATCH
ORIGINAL	0.011	0.064	0.003	0.389
SPIKED SAMPLE	1.14	1.14	1.12	1.47
SPIKE ADDED	1.00	1.00	1.00	1.00
% RECOVERY	112.90%	107.60%	111.70%	108.10%
QC CHECK (mg/l)				
	1.02	1.02	1.06	0.994
TRUE	1.00	1.00	1.00	1.00
% RECOVERY	102.00%	101.80%	105.70%	99.40%
PREP BLANK	<0.003	0.005	<0.003	<0.005

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

Submitted By:

Steven Lazoff
Laboratory Director

Hero71-08

HERRERA ENVIRONMENTAL CONSULTANTS
2200 Sixth Avenue, Suite 601
Seattle, Washington 98121
(206)441-9080
FAX 441-9108

CHAIN OF CUSTODY RECORD

page ___ of ___

PROJECT NAME	PROJECT NUMBER	CLIENT
520WQ	04-02916-007	HEC
REPORT TO: John Lenth - HEC		COPY TO:
SAMPLED BY: John Lenth - HEC		DELIVERY METHOD: Hand
LABORATORY: ART	REQUESTED COMPLETION DATE:	TOTAL # OF CONTAINERS:
LAB USE:		# OF CONTAINERS

SAMPLE ID	DATE	TIME	SAMPLE DESCRIPTION	# OF CONTAINERS	Dissolved Copper	Dissolved Zinc	Total Copper	Total Zinc
HH-DE-1	3/26/05	8:00	Stormwater I90R-	1	X	X	X	X
LVM-DS-1	3/26/05	8:19	↓	1	↓	↓	↓	↓
HH-DS-1	3/26/05	8:26		1				
LVM-DE-1	3/26/05	8:38	↓	1	↓	↓	↓	↓

ANALYSES REQUESTED

REMARKS: Metals Filtered 3/27/05 SL

RELINQUISHED BY (NAME/CO.)	SIGNATURE	DATE/TIME	RECEIVED BY (NAME/CO.)	SIGNATURE	DATE/TIME
John Lenth		3/26/05 9:24	Bob Zisette		3/27/05 0910
Bob Zisette		3/27/05 0930	Steven Lazoff		3/27/05 0930

HERRERA ENVIRONMENTAL CONSULTANTS

Data Quality Assurance Worksheet

By: John Lenth
Date: 4-29-05 Page ___ of ___
Checked initials: ___
date: ___

Project Name/No./Client: 520BRIDGEWQ / 04-02916-007 / WSDOT
Laboratory/Parameters: ARI / Total & Dissolved Cu, Zn
Sample Date/Sample ID: 3-26-05 / I90 Bridge

Parameter	Completeness/ Methodology	Holding Times	Blanks/ Detection Limits	Matrix Spikes/ Surrogate Recoveries	Lab Duplicates	Field Duplicates	Lab Control Samples	Instrument Calibration/ Performance	ACTION
Total Copper	O.K.	O.K.	<0.003 0.003 O.K.	112.9% O.K.	8.70% O.K.	NA	102.0% O.K.	O.K.	None
Total Zinc	O.K.	O.K.	0.005 0.005 O.K.	107.6% O.K.	7.52% O.K.	NA	101.8% O.K.	O.K.	None
Dissolved Copper	O.K.	25 hours elapsed before samples were filtered. Monitoring plan specifies filtration within 12 hours	<0.003 0.003 O.K.	111.7% O.K.	0.00% O.K.	NA	105.7% O.K.	O.K.	Values flagged as estimates
Dissolved Zinc	O.K.	25 hours elapsed before samples were filtered. Monitoring plan specifies filtration within 12 hours	<0.005 0.005 O.K.	108.1% O.K.	1.03% O.K.	NA	99.4% O.K.	O.K.	Values flagged as estimates

NA: Not applicable.

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**HER071-14**	**PAGE 1**	
REPORT DATE:	**04/28/05**		
DATE SAMPLED:	**04/01/05**	**DATE RECEIVED:**	**04/01/05**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

CASE NARRATIVE

Thirteen water samples were received by the laboratory in good condition. Samples for total recoverable metals analysis were digested according to EPA procedures. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

	TOTAL METALS		DISSOLVED METALS	
SAMPLE ID	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)
DS-N1	0.0201	0.765	0.0091	0.739
DS-S1	0.0202	8.070	0.0097	7.31
DS-N4	0.0235	0.137	0.0086	0.105
DS-S4	0.0192	0.409	0.0142	0.420
DE-S4	0.0441	0.177	0.0154	0.072
DS-N9	0.0164	0.220	0.0094	0.211
DS-S9	0.0311	0.161	0.0196	0.145
DE-S9	0.0496	0.288	0.0207	0.108
DE-DRAWSPAN	0.0112	0.130	0.0049	0.095
RAINWATER			<0.0010	0.018
FIELD DUP	0.0246	0.140	0.0083	0.082
DS-N20	0.0225	1.03	0.0119	0.875
DS-S20	0.0219	1.65	0.0172	1.61

HGR071-14

HERRERA ENVIRONMENTAL CONSULTANTS
2200 Sixth Avenue, Suite 1100
Seattle, Washington 98121
(206) 441-9080
FAX (206) 441-9108

CHAIN OF CUSTODY RECORD

PROJECT NAME: SR520 Bridge	PROJECT NUMBER: 04-2916-007
CLIENT: Herrera Environmental Consultants	
REPORT TO: J. Lenth	COPY TO:
SAMPLED BY: Dan Bennett	DELIVERY METHOD: Hand
LABORATORY: Aquatic Research Inc.	REQUESTED COMPLETION DATE: 30 days
TOTAL # OF CONTAINERS: 11	LAB USE:

ANALYSES REQUESTED

As per Dan on phone 4/1/05 → Only for RAINWATER sample

SAMPLE ID:	DATE:	TIME:	SAMPLE DESCRIPTION	# OF CONTAINERS:	dissolved copper	~~Total copper~~	dissolved zinc	~~Total zinc~~	
DS-N1	4/1/05	5:30	Storm flow	1	x	x	x	x	
DS-S1	↓	5:40	Storm flow	1	x	x	x	x	
DS-N4		5:50	Storm flow	1	x	x	x	x	
DS-S4		6:00	Storm flow	1	x	x	x	x	
DE-S4		6:15	Storm flow	1	x	x	x	x	
DS-N9		6:30	Storm flow	1	x	x	x	x	
DS-S9		6:35	Storm flow	1	x	x	x	x	
DE-S9		6:45	Storm flow	1	x	x	x	x	
DE-DRAWSPAN		5:20	Storm flow	1	x	x	x	x	
RAINWATER		7:20	Storm flow	1	x	[hatched]	x	[hatched]	*
Field Duplicate	↓	--	Storm flow	1	x	x	x	x	
~~Tranfer Blank~~				~~1~~	x	x	x	x	
DS-N20	↓	6:55	Storm flow	1	X	X	V	Y	
DS-S20	↓	7:00	Storm flow	1	Y	Y	Y	X	

REMARKS: ~~Please composite the three 1-liter bottles berfore analysis. TPH and Fecal coliform bottles were filled 1/3 of the way in each of three rounds from 11:05 to 13:05.~~

RELINQUISHED BY (NAME/CO.):	SIGNATURE:	DATE/TIME:	RECEIVED BY (NAME/CO.):	SIGNATURE:	DATE/TIME:
Dan Bennett (Herrera Environmental)	[signature]	4/1/05 13:00	[signature] ARI	S. Nielson	4/1/05 1300
RELINQUISHED BY (NAME/CO.):	SIGNATURE:	DATE/TIME:	RECEIVED BY (NAME/CO.):	SIGNATURE:	DATE/TIME:

HERRERA ENVIRONMENTAL CONSULTANTS

Data Quality Assurance Worksheet

By: John Lenth
Date: 9-29-05 Page 1 of 1
Checked initials:
date:

Project Name/No./Client: 520 BRIDGE WQ / 04-02916-007 / WSDOT
Laboratory/Parameters: ARI / Total & Dissolved Cu, Zn
Sample Date/Sample ID: 4-1-05 / SR520 Bridge

Parameter	Completeness/ Methodology	Holding Times	Blanks/ Detection Limits	Matrix Spikes/ Surrogate Recoveries	Lab Duplicates	Field Duplicates	Lab Control Samples	Instrument Calibration/ Performance	ACTION
Total Copper	OK	OK.	<0.0010 0.0010 OK	105.1% OK	10.2% OK.	4.57% OK	92.8% OK.	OK	None
Total Zinc	OK.	OK.	<0.005 0.005 OK.	108.8% OK.	3.77% OK	2.17% OK.	99.3% OK.	OK.	None
Dissolved Copper	OK	OK	<0.0010 0.0010 OK.	92.7% OK	< 2 times the detection limit OK.	3.55% OK.	92.8% OK	OK.	None
Dissolved Zinc	OK	OK.	<0.005 0.005	105.2% OK.	0.994% OK	24.6%	100.5%	OK.	None

Notes:

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**HER071-15**	**PAGE 1**	
REPORT DATE:	**05/06/05**		
DATE SAMPLED:	**04/07/05**	**DATE RECEIVED:**	**04/13/05**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

CASE NARRATIVE

Three water samples were received by the laboratory in good condition. Samples for total recoverable metals analysis were digested according to EPA procedures. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

	TOTAL METALS		DISSOLVED METALS	
SAMPLE ID	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)
EAST DOWNSPOUT 40'	0.0061	0.127	0.0039	0.099
EAST DOWNSPOUT 10'	0.0050	0.105	0.0023	0.088
WEST BRIDGE DECK DRAIN	0.0091	0.022	0.0051	0.006

= East Downspout

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: HER071-15 **PAGE 2**

REPORT DATE: 05/06/05

DATE SAMPLED: 04/07/05 **DATE RECEIVED:** 04/13/05

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

QA/QC DATA

	TOTAL METALS		DISSOLVED	
QC PARAMETER	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)
METHOD	EPA 220.2	EPA 200.7	EPA 220.2	EPA 200.7
DATE PREPARED	04/14/05	04/14/05	04/13/05	04/13/05
DATE ANALYZED	04/28/05	05/05/05	04/22/05	04/29/05
DETECTION LIMIT	0.0010	0.005	0.0010	0.005
DUPLICATE				
SAMPLE ID	BATCH	BATCH	BATCH	WEST BRIDGE DECK DRAIN
ORIGINAL	<0.0010	0.004	0.0134	0.006
DUPLICATE	<0.0010	0.004	0.0135	0.006
RPD	NC	7.43%	0.52%	3.76%
SPIKE SAMPLE				
SAMPLE ID	BATCH	BATCH	BATCH	WEST BRIDGE DECK DRAIN
ORIGINAL	<0.0010	0.004	0.0134	0.006
SPIKED SAMPLE	0.0261	0.981	0.0244	1.00
SPIKE ADDED	0.0250	1.00	0.0125	1.00
% RECOVERY	104.20%	97.70%	88.00%	99.45%
QC CHECK (mg/l)				
	0.0253	0.971	0.0251	0.983
TRUE	0.0250	1.00	0.0250	1.00
% RECOVERY	101.20%	97.08%	100.40%	98.29%
PREP BLANK	<0.0010	<0.005	<0.0010	<0.005

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

Submitted By:

Steven Lazoff
Laboratory Director

HERO71-15

Attn: JANA

Aquatic Research Incorporated
3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

CHAIN-OF-CUSTODY RECORD

CLIENT: WSDOT
SAMPLING DATE: 4/7/05
SAMPLERS: Jana Crawford

SHEET 1 OF 1
PROJECT ID:
CASE FILE NO.:
DATA RECORDED BY:

SAMPLE INFORMATION

BILLING: RESULTS TO HERRERA. Jana Lantz

SAMPLE ID	DATE/TIME COLLECTED	Total Dissolved Copper	PARAMETERS	NOTES
East Downspout 40'	4/7/05 1:30	X		
East Downspout 10'	4/7/05 1:40	X		
West Bridge Deck Drain	4/7/05 1:45	X		

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name	Jana Crawford	4/8/05	J. Nielsen	4/13/05
Signature	Jana Crawford			1130
Affiliation	WSDOT		ARI	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.): ** Please call for billing instructions before analysis Jana Crawford (360) 570-6449 or Richard Iverson (360) 570-6648. Thanks

HERRERA
ENVIRONMENTAL
CONSULTANTS

Data Quality Assurance Worksheet

By John Lenth

Project Name/No./Client: WQSAMP520 / 04-02616-007 / WSDOT

Date 05-16-05 Page 1 of 1

Laboratory/Parameters: Aquatic Research Incorporated / Total and Dissolved Cu, Zn

Checked: initials

Sample Date/Sample ID: 03-04-05 / Hood Canal Bridge

date

Parameter	Completeness/ Methodology	Holding Times	Blanks/ Detection Limit	Matrix Spikes/ Surrogate Recoveries	Lab Duplicate RPD	Field Duplicate RPD	Control Sample Recovery	ACTION
Total Copper	OK	OK	<0.0010 mg/L 0.0010 mg/L	104.2 % O.K.	NC	NA	1001.2 % O.K.	None
Total Zinc	OK	OK	<0.005 NTU 0.005 NTU	97.7 % O.K.	7.43 % O.K.	NA	97.8 % O.K.	None
Dissolved Copper	OK	154 hours elapsed before samples were filtered. Monitoring plan specifies filtration within 12-hours.	<0.0010 mg/L 0.0010 mg/L	88.0 % O.K.	0.52 % O.K.	NA	100.4 % O.K.	Values flagged as estimates
Dissolved Zinc	OK	154 hours elapsed before samples were filtered. Monitoring plan specifies filtration within 12-hours.	<0.002 mg/L 0.002 mg/L	99.4 % O.K.	3.76 % O.K.	NA	98.2 % O.K.	Values flagged as estimates

NA NOT APPLICABLE OR NOT AVAILIBLE

NC NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING LESS THAN THE DETECTION LIMIT

APPENDIX D

Laboratory Reports for Metallurgical Analyses

DWIGHT COMPANY, Inc.

WELDING LABORATORY SERVICE

414 HEWITT RD, CHEHALIS, WA., 98532; 360-262- 9844, FAX 360-262-9404, e-mail: dwight@weldlab.com

w w w . w e l d l a b . c o m

Herrera Environmental Consultants, Inc.	Date :	**Monday, June 13, 2005**
2200 Sixth Avenue, Suite 1100		
Seattle, Washington 98121	Project No.	**04-02916-007**
Attention: Mr. John Lenth, P.E.	Fax:	**206-441-9108**

Metallurgical Analysis of Galvanized Drain Pipe Coating - 2005

BACKGROUND:

Two short lengths of steel bridge deck drain pipe have been provided to the Dwight Company.

These pipe segments were removed for chemical and metallurgical analysis.

The first segment marked (*SR-520 pipe*) was removed from the SR-520 deck drain system.

The second segment marked (*HR*) was removed from the Hood Canal bridge deck drain system.

An uncharacteristically high zinc effluent value was obtained during a routine drain water analysis on the SR-520 deck drain system.

Both floating bridges have similar drain pipe effluent systems with “HOT DIP Galvanized” coatings. These components generally meet the requirements of ASTM A-123, Grade 100 with a coating thickness of 3.9 mils minimum.

OBJECTIVES OF TEST WORK:

1. To determine the ID galvanized coating chemistries on SR-520 & HC samples.
2. To determine the base metal carbon steel chemistries on SR-520 & HC samples.
3. To examine and compare the coating thickness and metallurgy of both samples.
4. To perform a micro-probe analysis using S.E.M. on the ID galvanized coatings.

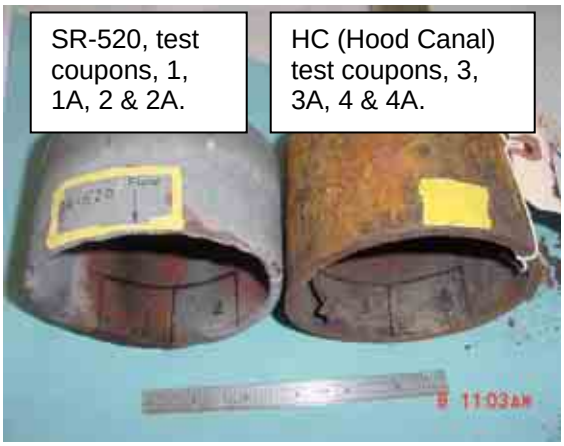

Figure 1, Shows the field samples received for metallurgical analysis.

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Figure 2, Shows the four (4) test coupons removed from each field sample. There are a total of 8 coupons.

SPECIMENS REMOVED FOR ANALYSIS:

Eight (8) test coupons were removed. Four (4) of these were mounted for examination on the inverted light microscope. The samples are shown in Figures 3 and 4.

Figure 3, Shows the SR-520 galvanized pipe coupon numbers 1 and 2.

SR – 520 Mounted Samples:

The SR-520 coupons are mounted so the plating and base metal is shown in cross section. Micrographs will concentrate on the galvanized plating.

Hood Canal (HC) Mounted Samples:

The Hood Canal (HC) coupons are also mounted so the plating and base metal is shown in cross section.

Note: *The Hood Canal (HC) samples are in very poor condition. There appears from the initial visual inspection of these coupons that a*lmost *no galvanized coating remains.*

Figure 4, Shows the Hood Canal (HC) galvanized pipe coupon numbers 3 and 4.

Base Metal Chemistry:

These specimens were prepared for analysis by removing all galvanized coating.

The blanks shown in Figure 5 were analyzed using an NIST trace instrument. The base metal zinc weight % is at the residual element level approaching 0.0 wt %.

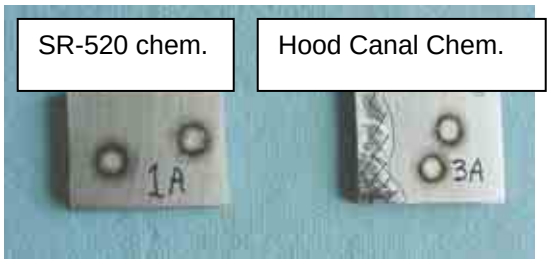


Figure 5, Shows the SR-520 and HC spectrographic chemistry blanks.

Summary Table of Chemistry Results

Pipe	C	Mn	Si	P	S	Cr	Ni	Mo	Zn	Cu	B	V	Fe
1A	.08	.39	.005	.065	.036	.009	.013	.014	0.0	.0148	.0003	.013	BAL
3A	.109	.42	.005	.062	.026	.017	.021	<.014	0.0	.09	.0003	.012	BAL

Both pipe base metals are low carbon mild steels.

Metallurgical Test Results

The following series of Microphotos compare cross sections removed from the SR-520 and Hood Canal bridge deck drains. The galvanized coatings show typical layers of metallic zinc with a first tinning coat and vertical dendrites on the second coat.

Test Specimen Detail on SR-520

Specimen 2, shown in Figure 6 is typical of SR-520 specimens.

Microphoto Features:

- Low carbon steel pipe
- Initial zinc tinning coat
- Second dip coat with columnar grains
- Sponge region with pits
- Thin metallic zinc layer

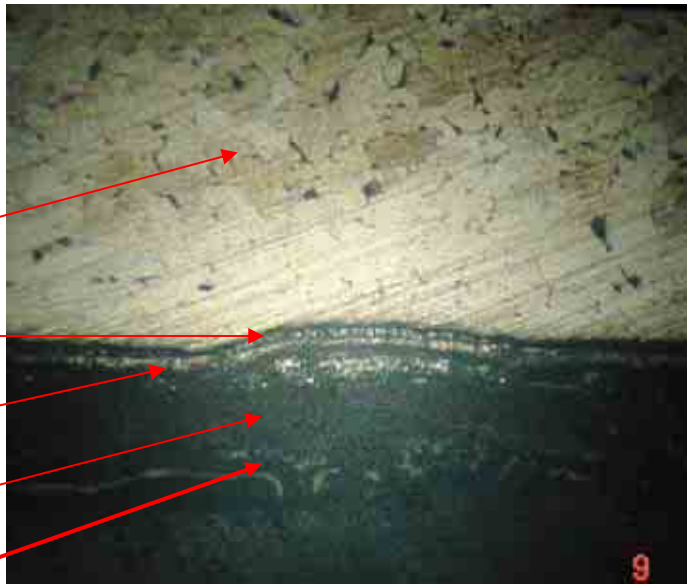


Figure 6, Specimen shown at 300X magnification.

Figure 7 shows a close-up of the Sponge region. This is an enlargement of Figure 6 above. The Figure 7 digital photo below is 600X magnification.

Significant Features of sponge region:

- Low carbon steel pipe
- Initial zinc tin coat
- Corrosion pitting
- Galvanized zinc remnants

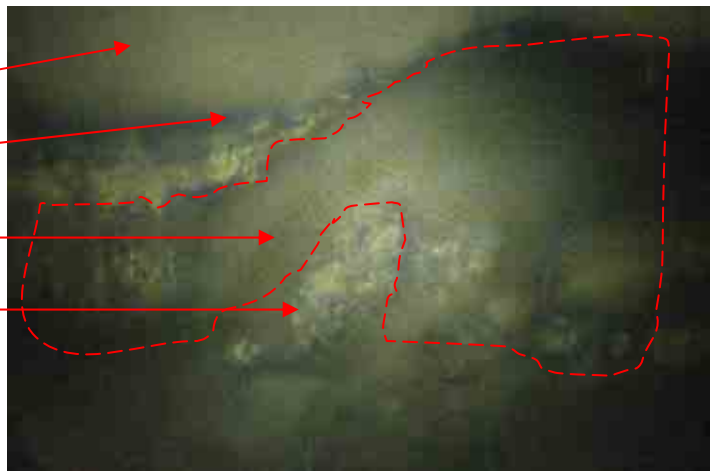


Figure 7, 600X magnification of zinc corrosion cell .

The high zinc content in the effluent is probably related to the combined presence of zinc rich sponge regions and cell corrosion pits on the pipe ID galvanized surface. The sponge regions may be areas that provided the metallic zinc in solution and are now zinc depleted zones.

Test Specimen Detail on ID of HC (Hood Canal)

Specimen 3 shown in Figure 8 is typical of the Hood Canal (HC) ID galvanized surface.

Microphoto Features:

- Low carbon steel pipe
- First tinning zinc layer
- Second dip coat
- NO SPONGE REGION
- Mounting epoxy

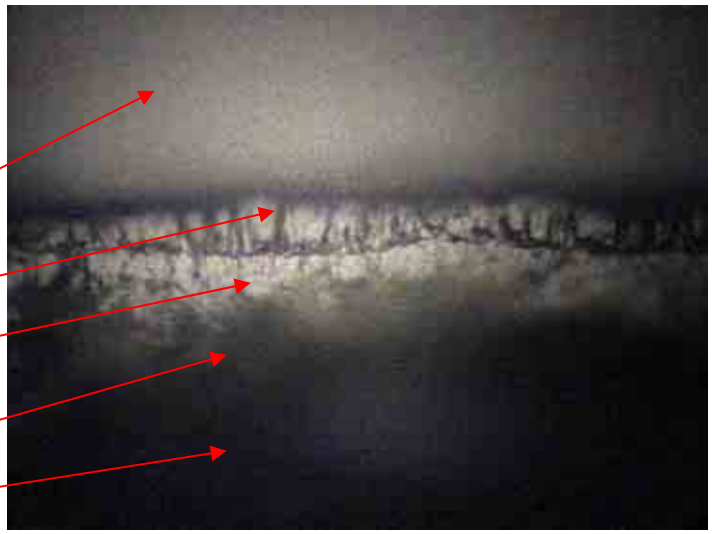


Figure 8, Specimen showing the Hood Canal ID galvanized surface. Note the intact second dip coat.

Specimen 3 in Figure 8 is typical of galvanized surfaces examined on other WSDOT components. The Hood Canal (HC) coupon does not show the heavy SPONGE REGION visible on the SR-520 samples.

Test Specimen Detail on OD of HC

The base metal microstructure of specimen 3, Figure 9, is ferrite (light) and pearlite (dark). The irregular OD surface is shown at the top of the microphoto.

Loss of the galvanized OD surface resulted from accelerated pitting corrosion.

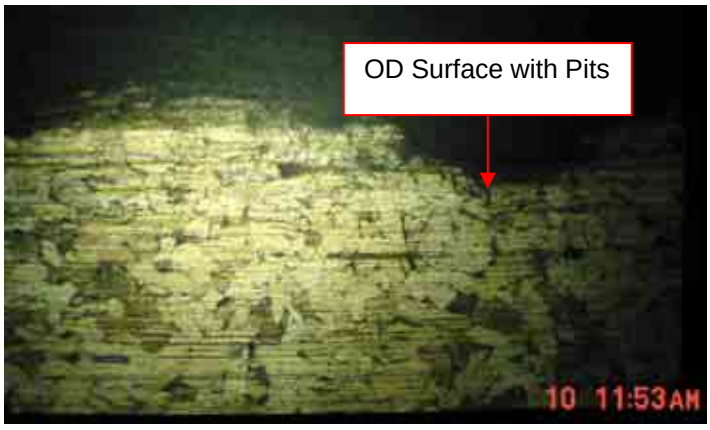


Figure 9, Shows a 400 x microphoto of specimen 3 OD. Note the complete absence of galvanized coat. The HC coupon OD is typical of a severely corroded steel surface.

CONCLUSIONS:

1. The galvanized coatings on both the SR-520 and HC test coupons show typical layers of metallic zinc with a first tinning coat and vertical dendrites on the second coat. The major difference observed between the two drain system pipe ID coatings are:

    a. The presence of a relatively thick sponge layer on the SR-520 samples.

    b. Significant cell corrosion on the SR-520 samples.

2. The high zinc content in the effluent of the SR-520 drain system is probably related to the combined presence of zinc rich sponge regions and cell corrosion pits on the pipe ID galvanized surface.

3. The Hood Canal (HC) coupons do not show the heavy SPONGE REGION visible on the SR-520 samples.

4. The Hood Canal (HC) OD coupon is typical of a severely corroded steel surface with large pits.

5. The ID galvanized coating on both HC specimens were still intact.

RECOMENDATIONS: (for effluent control in sensitive bridge locations)

1. I would recommend that **future drain ID galvanized coats** control the amount of dross or sponge that is deposited in the HOT DIP GALVANIZING PROCESS.

2. It may be necessary to call out a surface finish with dross or sponge regions limited to a maximum area of the pipe ID. It may also be necessary to limit the finish HOT DIP GALVANIZING thickness.

We certify that the material covered by this report has been inspected and/or tested in accordance with the applicable requirement described herein, and that test reports are on file subject to examination by qualified auditors.

Notarized if Required	*J. M. Dwight*	**Welding Engineer**
	Signature	Title

June 14, 2005

Dwight Co.
Attn: Jay Dwight
414 Hewitt Rd.
Chehalis, WA 98532
E-mail: Dwight@weldlab.com

LISIN
METALLURGICAL
SERVICES

Subject: Examination Of Galvanized Pipe Samples
Lisin Metallurgical Services Job No. 252-05-002
PO No. 102-05

Dear Mr. Dwight,

Two pipe sample coupons were submitted for analysis of an apparent galvanized coating. The pipe sample coupons were identified as Samples 2A and 4A. It was reported that the samples were removed from a culvert, and that elevated zinc levels were detected in the vicinity of the culvert. We were asked to confirm that the samples had been galvanized or otherwise coated with zinc, and to comment on the quality of the coating.

Significant results of our analysis are as follows:

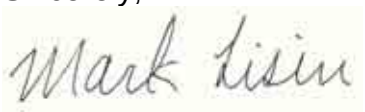
1) The OD and ID surface of Sample 2A and the ID surface of Sample 4A exhibited a matte gray finish with only superficial rust stains. The appearance was consistent with a galvanized coating. The OD surface of Sample 4A was substantially corroded. The samples appear in the as-received condition in Figure 1.
2) Energy dispersive x-ray (EDX) analysis of the as-received ID surfaces revealed predominantly zinc and iron. Lesser amounts of oxygen, aluminum, silicon, phosphorus, sulfur, and calcium were also detected. Analyses of the ID surfaces of the coupons appear in Figure 2.
3) Examination of metallographic sections through the ID and OD surface of Sample 2A and the ID surface of Sample 4A revealed a dense, adherent metallic layer. The layer exhibited a columnar, dendritic microstructure. These features are consistent with a galvanized coating. No evidence of an apparent galvanized layer was revealed by the metallographic examination of the OD surface of Sample 4A. Metallographic sections through both coupons appear in Figures 3 and 4.
4) EDX analysis of the ID coatings revealed only zinc and iron. The composition is consistent with a galvanized coating. EDX analyses of the ID coatings appear in Figures 5 and 6.

5) Corrosion products penetrated along the dendrite boundaries of the galvanizing. The appearance suggests substantial corrosion of the galvanized coating. Corrosion of the galvanized layer can be seen in Figures 3 through 6.

6) The pH of the OD and ID deposits on both coupons was approximately 6 to 7 pH units. Application of dilute hydrochloric acid to the surfaces yielded no odor of hydrogen sulfide. These observations suggest that corrosion was not the result of excessively acidic or alkaline conditions or due to the presence of or formation of sulfides. However, the coupons were likely contaminated during handling and sectioning prior to our receipt, and the above results may not be definitive.

Thank you for working with us on this interesting project. Please feel free to call with any comments or questions.

Sincerely,



Mark A. Lisin, P.E.
Lisin Metallurgical Services

Figure 1
Magnifications 1X
Coupon samples in the as-received condition. The OD surfaces (left) and the ID surfaces (right) are shown.

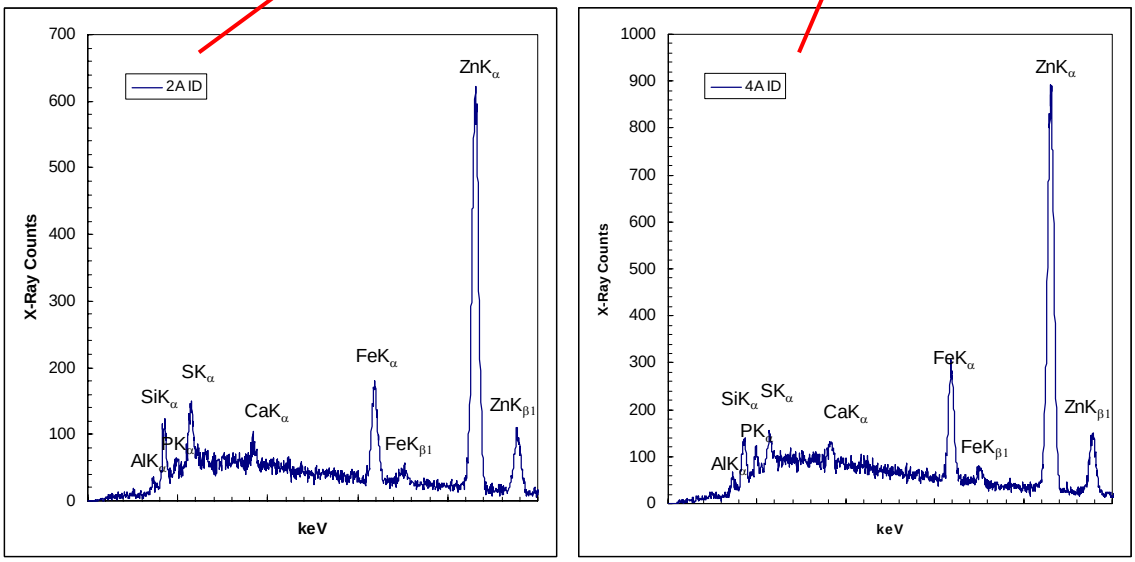


Figure 2
Energy dispersive x-ray spectra acquired from the ID surfaces. Large amounts of zinc, and lesser amounts of aluminum, silicon, phosphorus, sulfur, calcium, and iron were detected.

2A, ID 2A, OD

Figure 3

Magnification 320X

Transverse metallographic sections through the ID surface (left) and the OD surface (right) of Sample 2A. Both surfaces contain an inner metallic coating layer and an outer layer of corrosion products. Corrosion appears to penetrate along a columnar dendritic structure within the inner coating layer. This structure is characteristic of galvanizing. As-polished, brightfield illumination.

4A, ID 4A, OD

Figure 4

Magnification 320X

Transverse metallographic sections through the ID surface (left) and the OD surface (right) of Sample 4A. The ID surface contains an inner metallic coating layer and an outer layer of corrosion products. Corrosion appears to penetrate along a dendritic structure within the inner coating layer. This dendritic structure is characteristic of galvanizing. The OD surface is free of an apparent galvanized layer, and is heavily corroded. As-polished, brightfield illumination.

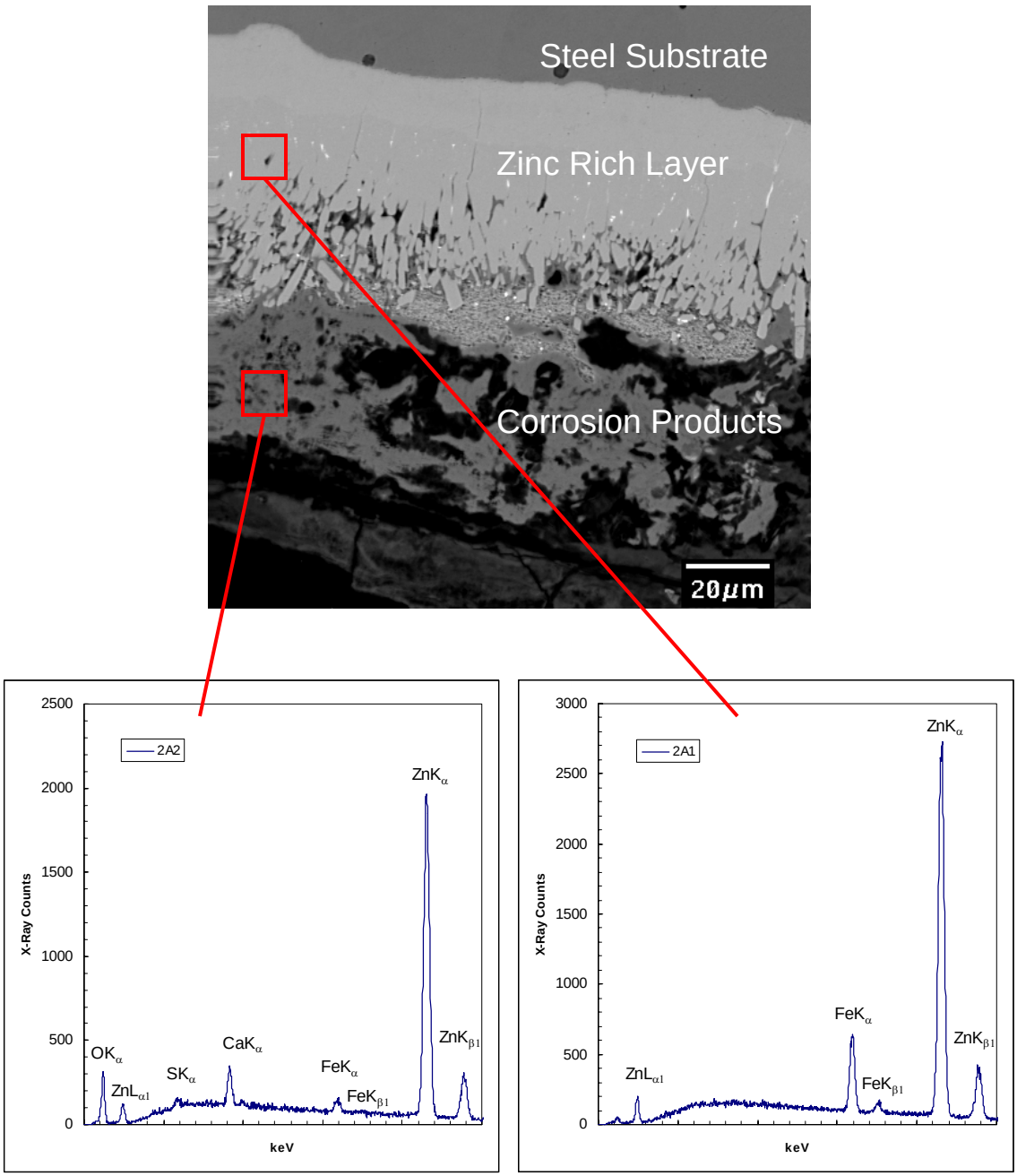


Figure 5
Backscattered electron image and energy dispersive x-ray spectra acquired from a metallographic section through the ID surface of Sample 2A. The inner layer consists of zinc and iron. The composition is consistent with galvanizing. The outer layer contains oxygen, sulfur, calcium, iron, and zinc.

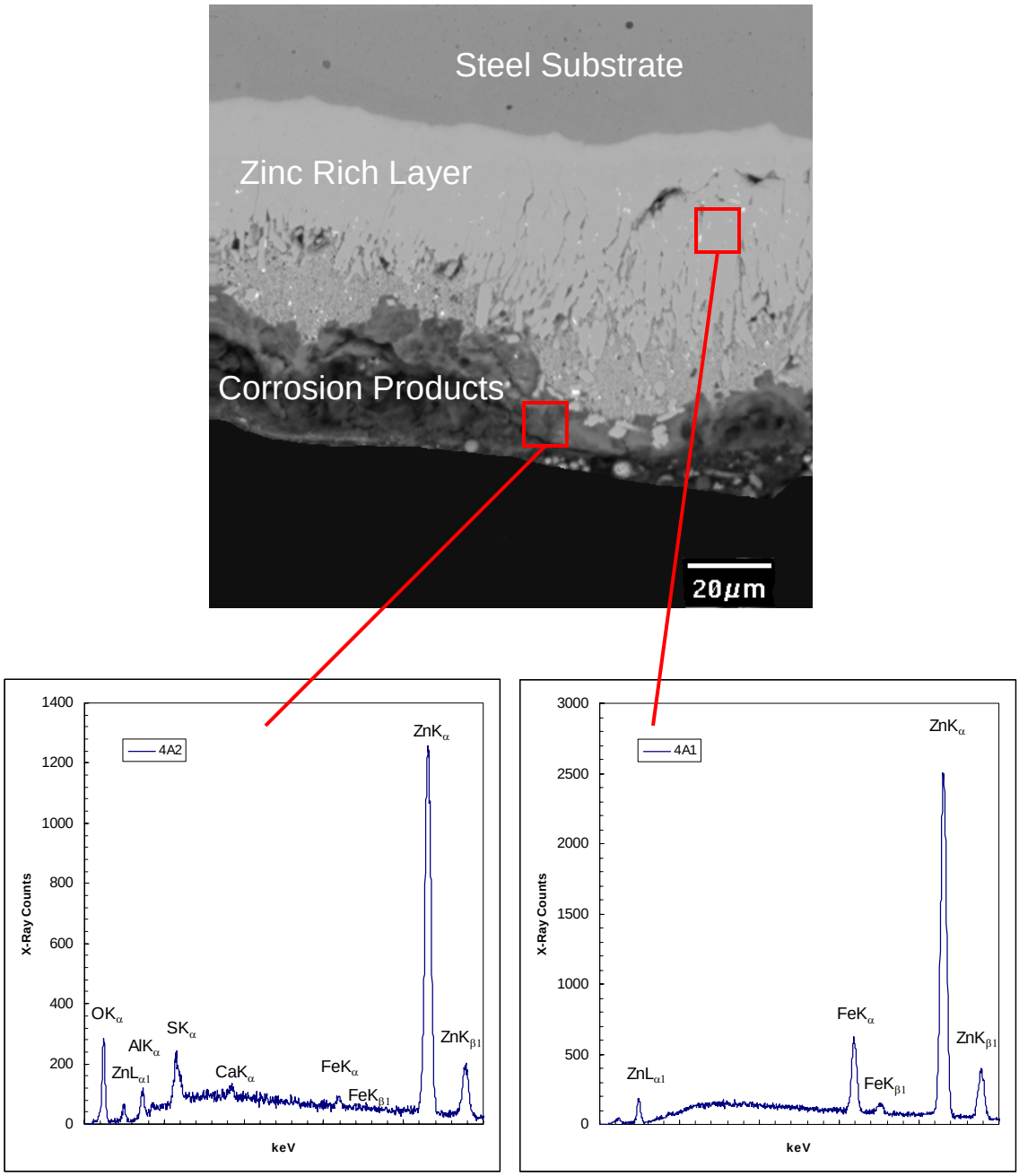


Figure 6
Backscattered electron image and energy dispersive x-ray spectra acquired from a metallographic section through the ID surface of Sample 4A. The inner layer consists of zinc and iron. The composition is consistent with galvanizing. The outer layer contains oxygen, aluminum, sulfur, calcium, iron, and zinc.